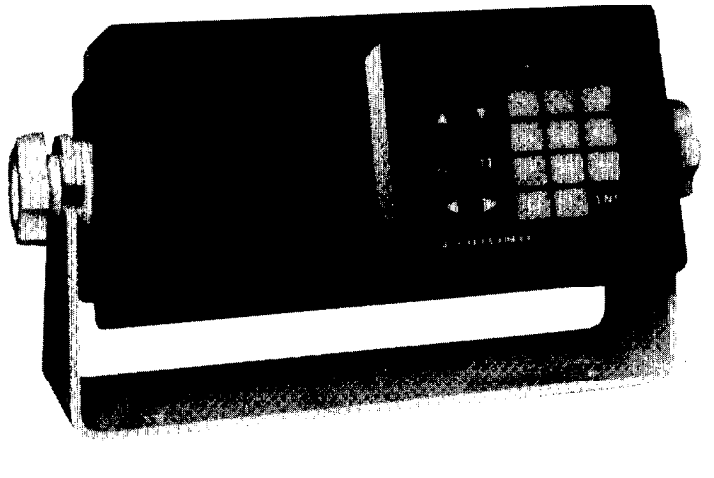
No. : OM-E4300-0B

FURUNO

OWNER'S MANUAL

LORAN C NAVIGATOR

MODEL LC-90



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INTRODUCTION

Congratulations on your choice of the Furuno LC-90 Loran-C navigator. We are confident that you will enjoy many years of operation with this fine piece of equipment.

For over 30 years Furuno Electric Company has enjoyed an enviable reputation for quality and reliability throughout the world. This dedication to excellence is furthered by our extensive global network of agents and dealers.

The LC-90 Loran-C receiver is just one of many Furuno developments in the field of navigation. Its compact size and ease of installation and operation make it suitable for use on a wide variety of vessels.

As with most modern instruments, time and experience are required to reap maximum benefit from your new receiver. To help you meet this end as quickly as possible, this manual is laid out in as "user friendly" a manner as possible. The first section covers Basic level operations and later sections cover Intermediate and Advanced operations.

This unit is designed and constructed to ensure the user of many years of trouble-free operation. However, to obtain optimum performance from this equipment, we ask that you read and follow the recommended procedures for installation, operation and maintenance. No machine can perform to the utmost of its ability unless it is installed and maintained properly.

We would appreciate feedback from you, the end-user, about whether we are achieving our purposes in this manual.

Thank you for considering and purchasing Furuno equipment.

CAUTION

Although your Loran C receiver is capable of providing very accurate position data, no single navigational device should ever be solely relied upon. Position information obtained from Loran-C should always be double-checked against other sources such as radar, visual and celestical sightings, sounding measurements, etc. to verify the reliability of the data.

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FEATURES

The LC-90 has a large variety of functions, all contained in a rugged die-cast aluminum case that is compact enough to fit almost any size of boat. Sealed-membrane touchpads provide positive, splashproof control of all functions displayed on the large five line LCD (Liquid Crystal Display) display.

Both the touchpads and the LCD display have variable backlighting for nighttime operation, and touchpad operations are confirmed by an audio tone.

The LC-90 features virtually "hands-off" automatic operation once it has been initialized for a specific geographic area, since selection of the proper GRI and the optimum slave secondaries is automatic, as is ASF compensation (Additional Secondary Factor) for accurate Latitude/Longitude readout, automatic Magnetic Variation for magnetic bearing readouts, and six automatic notch filters to eliminate interference. Each automatic function however may be manually overridden if the operator desires.

Entry and readout for all position functions may be by either Latitude and Longitude or by TD's (Time Differences) for maximum flexibility.

Navigation functions built into the LC-90 include:

- Position readout in Latitude/Longitude or Time Differences (TD's).
- Speed Made Good and Course Made Good.
- Velocity To Destination and Time To Go to destination.
- Range and Bearing to a waypoint and Range and Bearing from waypoint to waypoint. Bearing can be either True or Magnetic, with automatic Magnetic Variation built-in.
- Cross-Track Error, Direction to steer to get back to courseline, Course Offset, and Range to destination on one display screen.
- Entry of waypoint by Latitude/Longitude, TD's, by Range/Bearing from present position, or at Present Position.
- Route Planning and automatic Route following.
- Alarm limit setting for Cross Track Error alarm, Border alarm, Arrival alarm, and Anchor Watch alarm.
- Display of signal parameters: SNR (visual and audible indications), ECD, tracking point, and interference frequency and level, with six automatic notch filters built-in.
- Display of operational parameters: GRI slave selection, ASF or manual correction factors, auxiliary data output(s), and Event memory contents.

LC-90 SPECIFICATIONS

Receiving Frequency:	100 KHz
Receiver Sensitivity:	1 microVolt/m
Dynamic Range:	110 dB
Differential Dynamic Range:	80 dB
Interference Rejection:	Six automatic notch filters built-in. These may be manually operated if desired.
Tracking:	Master plus 5 secondaries (max.)
Tracking Speed:	80 kts
Settling Time:	5 min. nominal (depends on Loran signal conditions.)
Display Resolution:	TD: 0.1 microseconds. L/L: 0.01 minutes. Range: 0.01 n.m.
Alarm Indications:	Audible and visible, including Cross Track Error, Arrival, Border and Anchor Watch alarms.
Computational Base:	WGS-72 Range/Bearing: Great Circle.
Output Signals to Ext. Equipment:	Furuno CIF for course plotter, printer, scanning sonar, color video sounder; NMEA 0180 simple format for autopilot; NMEA 0183 complex format for plotters.
Ambient Temperature Range:	Display Unit: 0 to 50 deg. C. Ant. Coupler: -30 to 70 deg. C.
Power Supply:	10-42 VDC, universal, 9w. 110/220 VAC, 50-60 Hz, with external rectifier.
Weight:	Display Unit: 2.3 kg Antenna Coupler: 0.6 kg

COMPLETE SETS

	Name	Type	Code No.	Q'ty
1	Main Unit	LC-90	000-041-151	1
2	Antenna Coupler	AC-90C	000-041-152	1
3	Installation Materials		000-041-154	1set
4	Accessories		000-041-155	1set
5	Spare Parts		000-041-153	1set

INSTALLATION MATERIALS

	Name	Type	Code No.	Q'ty
1	Power Cable Assy.	OOS0120-0	000-104-058	1
2	Hose Clamp	SS7200N	000-570-239	1

ACCESSORIES

	Name	Type	Code No.	Q'ty
1	Bracket Assy.	FP04-00310	004-285-420	1
2	Knob Bolt	KG-B2 M8x20 SUS304	000-800-418	2
3	Tapping Screw	5x20 SUS304	000-800-488	4
4	Flat Washer	M5 SUS304	000-864-128	4

SPARE PARTS

	Name	Type	Code No.	Q'ty
1	Fuse	FGMB 2A 125V	000-103-165	2

OPTION

	Name	Type	Code No.	Q'ty
1	Rectifier	PR-62 AC 100V PR-62 AC 220V	000-013-484 000-013-486	1
2	Interface Kit	LC-1091	000-041-156	1
3	4m Antenna	OP-04-1	000-041-157	1
4	2.6m Whip Antenna	STYLE10-3 DCE	000-572-190	1

ELEMENTARY THEORY SECTION

The word "LORAN" is an acronym meaning LOng RAnge Navigation. The basic principles of Loran were developed during World War II, and the system implemented during that time was known as the Loran A system. The superior Loran-C system was developed later during the 1960's and was put into widespread service during the late 1970's.

Loran-C is one of several important radionavigation systems in use by mariners throughout the world today. Loran-C may be thought of as a medium-range system since it usually covers out to a maximum of 1200 miles from the transmitting station.

For very close-in, precision work, portable microwave positioning systems are often employed by such users as the offshore oil industry, and for short range medium-accuracy work, Decca navigation systems are used in some parts of the world.

For transoceanic voyages, Satellite Navigation and/or Omega receivers are used to provide the sort of coarse accuracy that is suitable on the open sea. In other words, it is rarely necessary to know your position down to the nearest meter when on an ocean voyage, provided that you are reasonably certain that you are within the shipping lane and not in any danger of running aground on some nearby atoll.

The Loran-C system was designed and established to provide excellent accuracy in the region known as the "Coastal Confluence Zone," or CCZ as it is often called. This region extends from the shoreline seaward to the 100 fathom curve, or 50 nautical miles, whichever is greater.

Loran-C system accuracy is often capable of providing a reliable fix within 30 meters of one's actual position, but more typically, accuracy of about 100-200 meters is possible throughout the coverage area. However, system repeatability, that is, the ability to return to the same spot consistently, is usually on the order of 20-30 meters. Quite often it is even better than that.

Basic Navigation

The essential idea behind a scheme of positioning on the globe is that any particular point on the earth's surface can be uniquely described by the intersection of two lines: Latitude, girdling the earth horizontally (laterally) and Longitude, girdling the earth vertically.

Examine the section of chart shown next page (Fig. 1) depicting an area off Yokohama Japan. One can see the parallels of Latitude running East and West horizontally, and the meridians of Longitude running vertically North and South. Overprinted on this chart are so-called Loran-C Lines Of Position or TD's (Time Differences) as they are more commonly known. (We'll get into why they are called TD's later; suffice it to say for now that a Loran-C receiver will give you these numbers and that you can use these numbers to find your position.)

Note that the TD lines run at a variety of angles with respect to the lines running North/South or East/West. They are in fact actually curved lines, segments of hyperbolas. but this is difficult to see on this small section of

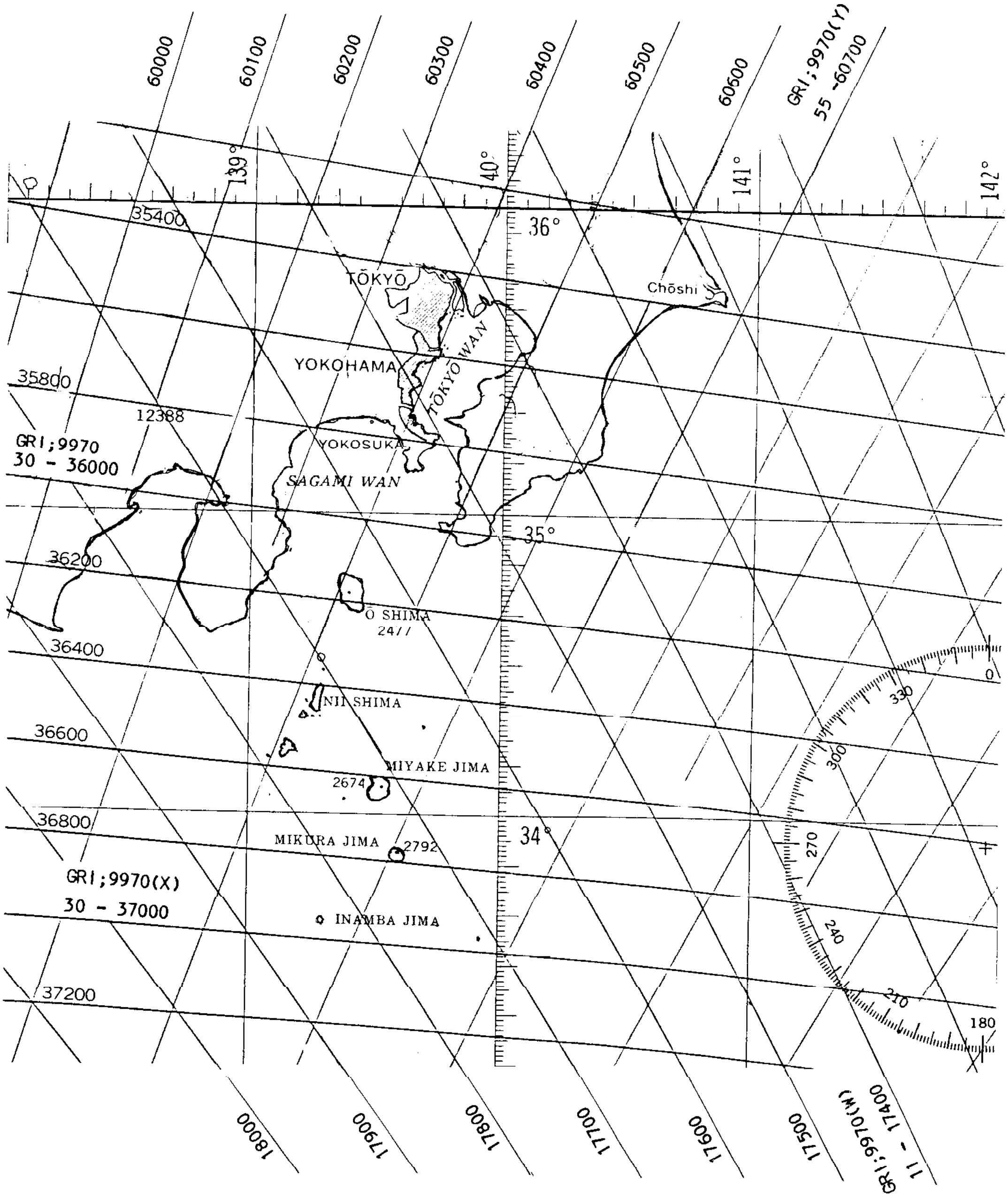


Fig. 1 Loran-C Chart off Yokohama

chart. These TD lines are labeled with numbers in units of microseconds on the outer edges of the chart. The spacing between adjacent TD's will vary depending on the scale of the chart as well as the section of geography being covered. Don't worry about these details just yet, but note that in this particular example the spacing between adjacent TD's is either 100 or 200 microseconds.

Just note that for any one position on the chart (that is, at any one particular Latitude and Longitude) there is at least one pair of Loran-C TD's that cross each other. There may in fact be more than one pair of TD's that cross each other at our one point of interest. Some of them may give you better accuracy than others. Again, we'll delve into that in more detail later.

As an example, let's find a point on the chart and compare the position both by Latitude/Longitude and by Loran-C TD's. At a Latitude of 33 degrees, 52 minutes North and a Longitude of 139 degrees, 35 minutes East you should find the Southeast corner of Mikura Jima Island. This position corresponds to the crossing of the two TD's lines of 36800 microseconds and 60600 microseconds. Note that a third TD crosses this position also, but that the exact line isn't printed on the chart explicitly--it is necessary to interpolate between lines that actually are printed in order to get this TD, and by so doing we would come up with a TD of approximately 17750 microseconds.

Now, let's consider in more detail the way Loran-C actually works.

HOW LORAN-C WORKS

The Loran-C system is a "pulsed" system whose fundamental assumption is that the speed of propagation of a radio wave is constant anywhere in the area of coverage of the system. This assumption is actually subject to some corrections, but we will assume for the sake of this discussion that the speed of a Loran-C signal is actually constant.

Since distance, time and speed are all related, and since we have assumed that the speed of the signal is constant, if we can devise some means to measure the time that it takes for a signal to arrive from a distant transmitter, we can easily calculate the distance the signal has travelled to get to us. Thank goodness for modern electronics, for it provides means for making very precise time measurements, down to the order of tenths of millionths of seconds.

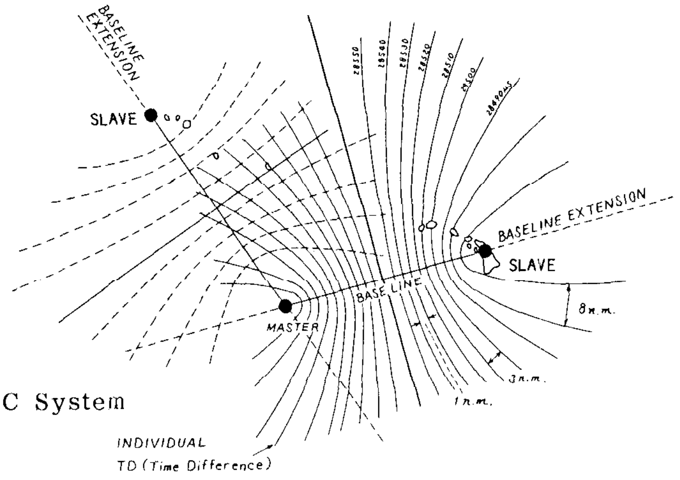


Fig. 2 Simple Loran-C System

A simple Loran-C system is shown in Fig. 2, consisting of a "master" transmitting station and two "slave" stations. This is the simplest configuration used. In practice, most of the chains in the world consist of three or four slave stations associated with each master. Note that the lines drawn connecting the master and each of the two slaves are known as "baselines."

To illustrate the basic idea behind the Loran-C system let us take a simple case, where the boat with the Loran-C receiver is located on one of the baselines and is in the middle between the master and the slave. If the transmitters were both to transmit simultaneously, the time taken for the signals from the master transmitter to arrive will be the same as that for the signals from the slave to arrive. In other words, the difference in arrival time will be zero.

If the boat is moved so that the time difference of signal arrival from master and slave is kept constant at zero, then the plot of these movements will be a straight line halfway between the slave and the master stations. This line will be perpendicular to the baseline. The line of constant time difference is known as a Line of Position, or LOP for short.

Other LOP's can be generated for conditions where the time difference isn't exactly zero, and these LOP's will form hyperbolas rather than the straight line in our simple case. (Radio navigation systems such as Loran-C are often referred to as "hyperbolic navigation" systems for this reason.)

If the master and its associated slaves were all to transmit simultaneously on the same frequency, the receiver would not be able to distinguish which station it was listening to in the resulting uproar. The stations therefore are arranged to transmit in a specific sequence of pulses, with very precisely defined time delays between the transmissions. So, for our simple case above where the LOP is in the middle of the baseline, the time difference is no longer zero, but is some specific value of TD.

The receiver's job is to use the start of reception of the master signal as a reference time to start its internal stopwatch. When the start of the slave signal is detected, the receiver in essence stops its internal stopwatch, notes the time difference, and displays it to the operator as a TD.

In order to determine where one is located on any particular Line of Position, another LOP is needed to intersect the first one. The Loran-C receiver thus must track more than one slave at the same time. Most modern receivers are capable of tracking all slaves available in the chain simultaneously.

The interval of time between the start of the master transmission, the series of slave transmissions and the next master transmission that repeats the whole sequence is called the Group Repetition Interval, or GRI. Each Loran-C chain in the world has a unique GRI assigned to it, and even though all Loran-C transmitters work on the same frequency (100 KHz), they can all be sorted out by GRI.

You will remember that the Time Difference's (TD's) are measured in microseconds (millionths of a second). Further, the designers of the Loran-C system have assigned an identifying letter code to each slave station in a chain. These are called either X, Y, W, or Z.

Now look back at the section of chart in Fig. 1 that shows part of the area near the coast of Japan. You can now better appreciate why the TD's are labeled as they are. The GRI in the label comes first, then the identifying code letter, and then the time difference in microseconds.

Your Loran-C receiver is considerably more sophisticated than the simple TD-only receivers we have been describing here. It is capable of computing Latitude and Longitude directly from these TD's.

This is a complex calculation, and again the fundamental assumption made is that the velocity of propagation of the signal is constant. While this is true for propagation over seawater, the velocity is altered slightly when the signals travel over land. Over land, the velocity is affected by such factors as the conductivity of the soil and the features of the terrain. These effects are all lumped together under the title of "Additional Secondary Factors," or ASF. These factors cannot be modeled exactly in the TD to Latitude/Longitude mathematical conversion.

The LC-90 however has TD offsets built-into it, describing deviations from the ideal grid. The offsets were actually measured at sea. The LC-90 can automatically take these warpages into account to give more accurate computation of Latitude and Longitude than can a receiver without this automatic ASF correction.

Note that the TD grids on a Loran-C overlaid chart can be shifted when the chart is printed and thus compensated to take care of actual observed readings from the field. One should still be careful when using Latitude/Longitude numbers directly from a Loran-C receiver, especially when near land since this is where significant errors can occur. (Note that the charts don't even show Loran-C grids over inland areas because of the extreme distortions in the lattices over land.) Also, Loran-C is not meant to be used in harbors or ports since these are usually surrounded by land masses.

Well, enough theory for now. Let's get down to how you actually operate your new receiver. Some advanced concepts and further cautions on the use (and misuse) of the system will be given later.

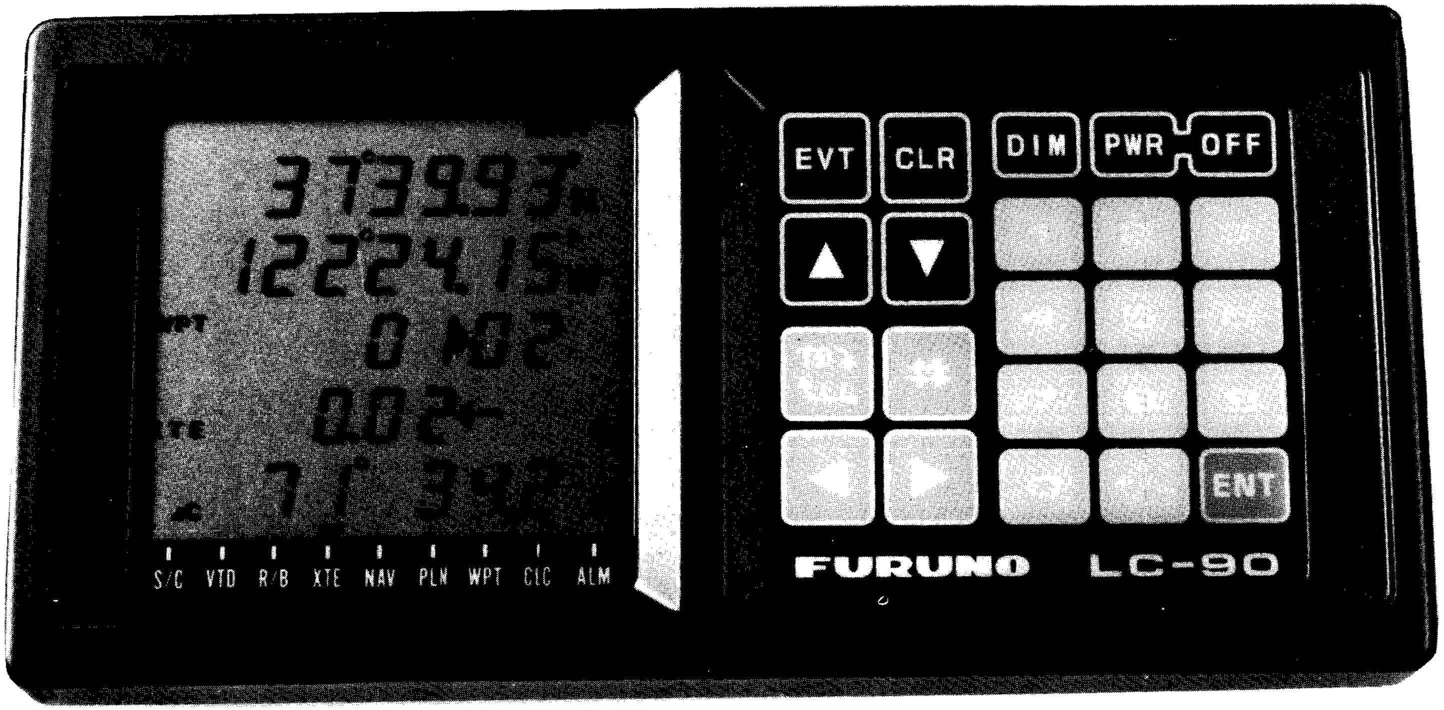


Fig.3 LC-90 Control Head Panel

OPERATIONAL OVERVIEW

The LC-90 is basically a rather simple unit to operate, although at first glance it may be a little intimidating to someone who has never used a Loran-C navigator before. However once you get to know what the various abbreviations mean, the simplicity and logic behind the layout and the design will become more apparent.

Examine the front panel. You will note that there is a large LCD readout taking up most of the left-hand side of the front panel, a keyboard on the right-hand side, and all sorts of abbreviations printed on the panel below the display. These nine abbreviated labels indicate the various Modes in which the LC-90 may be operated.

In addition, there are 10 secondary Functions which may be called up to do less-often used operations. These Functions are accessed by use of the [#] key, followed by a number from [0] to [9].

The keyboard itself contains twenty-three membrane-sealed touchpad keys, and is divided roughly into four functional areas, delineated by different color schemes. A distinctive "beep" is generated to confirm to the user that something did indeed occur whenever he presses a key.

The functional groupings of the touchpad keys are as follows:

POWER ON/OFF and DIMMER

These three brown keys are located at the top right of the keyboard. When the operator presses the [PWR] key, the LC-90 is activated. After several seconds, the display will begin to show some activity. It is necessary to press both the [PWR] and the [OFF] keys simultaneously in order to turn off power to the unit. This procedure is necessary to prevent unintentional interruption of power should the user accidentally hit the [PWR] key.

The [DIM] key is used to vary the level of backlighting of the display and keyboard for nighttime operation. There are four levels of backlighting intensity: bright, medium, dim and off. Each time the [DIM] key is pressed, the level will change in the above sequence.

NUMERIC KEYS

There are eleven numeric touchpad keys, and these are orange in color. The keys [0] through [9] are employed to enter all numeric data.

The [+/-] key is a general purpose key that is used to change from North to South latitude, or East to West longitude when entering data for Modes or Functions requiring Latitude/Longitude data, and which is also used to change default values for many Modes and Functions that can be used either automatically or manually. This key is also used to turn on/off many functions.

In each Mode or Function where data may be entered, leading zeroes must be specified (for ex., waypoint "01" must be entered fully, rather than as "1.") The LC-90 will reject entries it cannot understand where leading zeroes haven't been entered. Trailing zeroes needn't however be entered fully. For example, a latitude entry of "37" degrees is just as valid as the full entry of "370000" degrees.

OPERATING MODE/FUNCTION SELECTOR KEYS

The four blue keys on the lower left of the keyboard are the Mode selector keys. The two arrow shaped keys select which one of the nine Mode screens is in use. Pressing these keys causes the Mode indicator arrow to move sideways to align itself above the labels for the operating Mode on the panel beneath the LCD display. The readouts on the LCD itself will change in accordance with the Mode selected. Pressing the left arrow when the mode indicator is located at the left-hand edge of the panel will shift the indicator to the far right-hand Mode. Similarly, when the indicator is at the far right end, the arrow will shift the indicator to the far right-hand Mode.

The key labeled [#] is used to select one of the ten secondary Functions. It is first pressed followed by a number from [0] to [9] to acccess these secondary Functions. Note that it isn't necessary to press the [ENT] key to activate the Function. The LCD display will changed in accordance with the secondary Function selected by the operator.

The [TD ↔ L/L] key is used to change position data from Latitude/Longitude format to TD format and vice versa.

OTHER KEYS

At the top left of the keyboard there are four brown keys, the [EVT], [CLR] ▲ and ▼ keys. [EVT] stands for Event, and is used when a position is to be stored in the Event Memory or Waypoint Memory, or when an external plotter or printer is connected to the LC-90. The position at the moment this key is pressed is sent out to the external instrument.

The brown [CLR] key stands for Clear. It is used to clear a number from the display or to silence the audible alarm. The two arrow shaped keys ▲ and ▼ are used to select where the data entry cursor will be located on one of the five lines on the display. The cursor will be indicated by the flashing of the far left character on the desired line. Before typing in the new data, the operator presses the [CLR] key to clear the line, and after entering new data, the blue [ENT] key (standing for Enter) will be pressed. The cursor will automatically advance to the next line where data may be entered after the [ENT] key is pressed.

Note that if you accidentally type in the wrong data or if you hit the wrong key, you may hit the [CLR] key, followed by [ENT] to retrieve the data stored previously.

The following list shows a summary of the primary operating Modes, and the secondary Functions of which the LC-90 is capable of showing.

SUMMARY OF MODES AND FUNCTIONS

Primary Modes, Data Readouts:

S/C: Speed Made Good and Course Made Good, together with present position (in L/L or TD's, at the discretion of the operator) and the Route and/or Waypoints in use.

VTD: Velocity To Destination (in knots) and Time to Go (in Hours and Minutes), again together with present position and Route and/or Waypoints in use.

R/B: Range (in nautical miles) and Bearing (in degrees Magnetic or True, at the operator's discretion) from present position to destination waypoint, again together with present position and Route and/or Waypoints in use.

XTE: Cross-Track Error (in nautical miles off the desired track), with arrow indicators to show direction of offset and direction to steer to get back an track. As usual, present position and Route and/or Waypoints in use are shown. Course offset in degrees and Range to destination waypoint are displayed as well.

Primary Modes, Data Entry:

NAV: This is the Navigation Mode. The desired Route and/or Waypoint(s) desired are selected in this Mode. Cross-Track Error with Course offset and Range and Bearing to the desired waypoint are also displayed.

PLN: This is the Route Planning Mode. The waypoints involved in up to ten different Route Plans are selected in this mode.

WPT: This Mode is used to enter position data into a Waypoint. Waypoint data may be entered or recalled for confirmation either as L/L or as TD's.

CLC: This is the Calculation Mode. Trial rho-rho calculations of Range and Bearing from waypoint to waypoint may be done here. It is also possible to Define a waypoint by Range and Bearing from present position in this Mode.

ALM: This is the Mode where Alarm limits are defined for the Cross-Track Error alarm, the Border alarm, the Arrival alarm and the Anchor Watch alarm.

Secondary (#) Function:

In each of these function the blue [#] key is pressed, followed by a single number. To leave a secondary Function, hit either the left or right arrow keys.

#0: This is the Event Memory Function, where the operator can display the contents of each event memory.

#1: This is the Initialization Function. The user enters the approximate present position, and if he chooses to Disable automatic selection, the GRI and the slave secondaries for use by the LC-90.

#2: This is the Position Offset Function. The operator may enter the amount of delta L/L or delta TD offsets desired for a particular area. There are nine "pages" of offset information that may be stored in memory.

#3: This is the Averaging Time Function. The operator may choose the amount of smoothing time constant to be applied to the L/L and speed display. The type of output data available at the rear panel for external devices such as plotters or printers is specified in this Function as well.

#4: This is the automatic ASF (Additional Secondary Factor) and automatic Magnetic Variation Function. Both Functions may be disabled manually. The amount of ASF correction automatically used by the LC-90 in the present geographic area is displayed. Note that at 0 degrees variation, True North referenced bearings will be obtained.

#5: This is the Cycle Selection Function. The amount that the tracking point is ti be slewed manually is entered in this Function.

#6: In this function the SNR (Signal to Noise Ratio) and ECD (Envelope to Cycle Difference) are displayed. These numbers give the operator an indication of the quality of the incoming Loran signals. The display shows which cycle of the Master and two secondary stations the LC-90 is presently tracking, and shows in addition, the deviation of the internal reference oscillator from the ideal frequency.

#7: This Function is the SNR Visual/Audio Indicator. It allows the operator to make trial adjustments for example of the antenna location while watching the display or listening to the LC-90 buzzer remotely. The tracking point for the master and the two secondaries is also displayed, as well as the numerical SNR value for each station.

#8: This is the Tuning Indicator Function. The operator may display the level of signals, both interfering and desired, from 70 to 130 KHz.

#9: This is the Notch Filter status Function, where the frequency of each automatic notch filter may be displayed, and if desired where each of the six filters may be set manually on desired frequencies. The level of signal on the frequency of each filter is displayed as well.

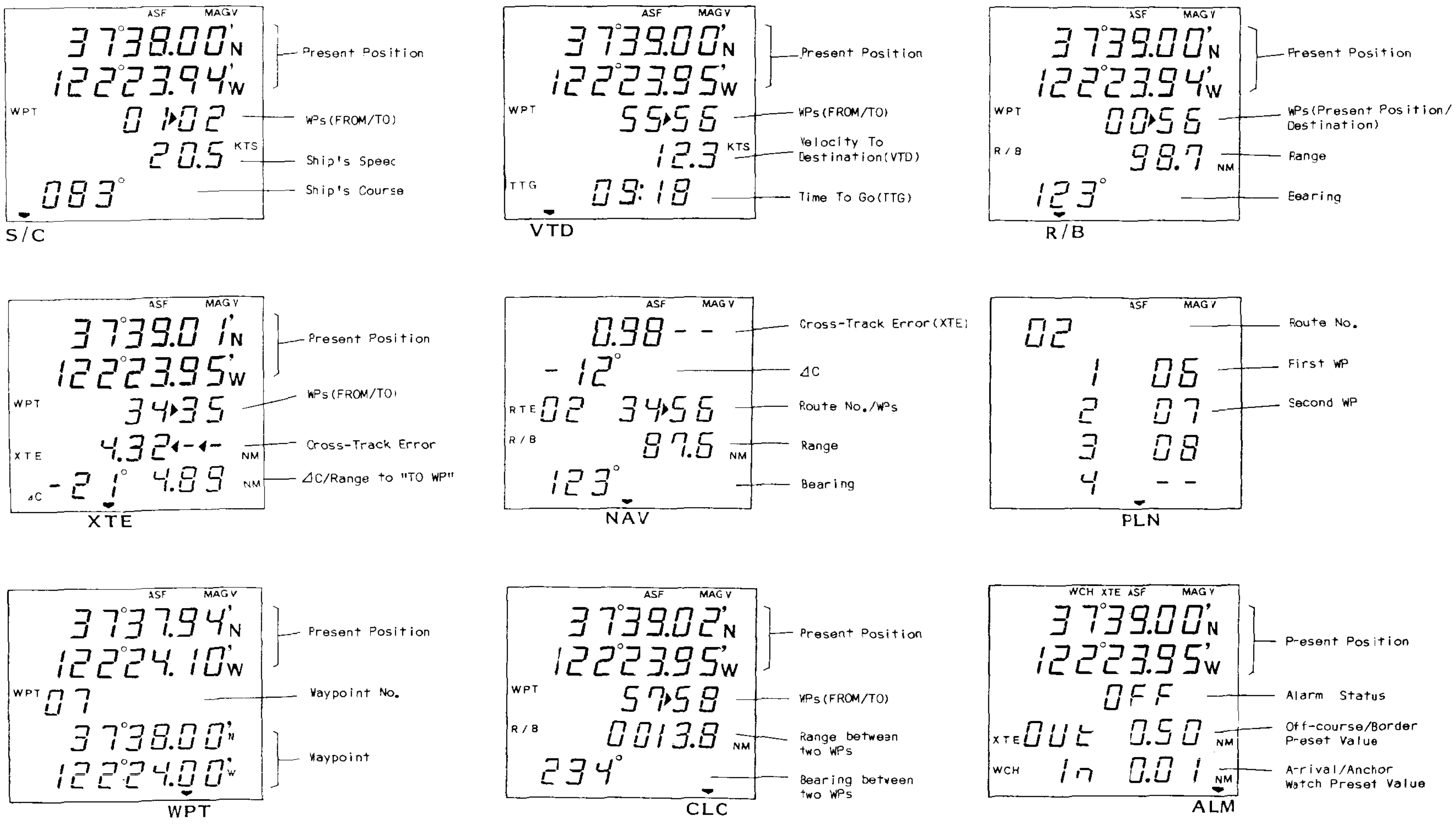


Fig. 4 Typical Mode Screens
(The above mode screens are placed in the order they are arranged on the panel below the display of the LC-90, from left to right.)

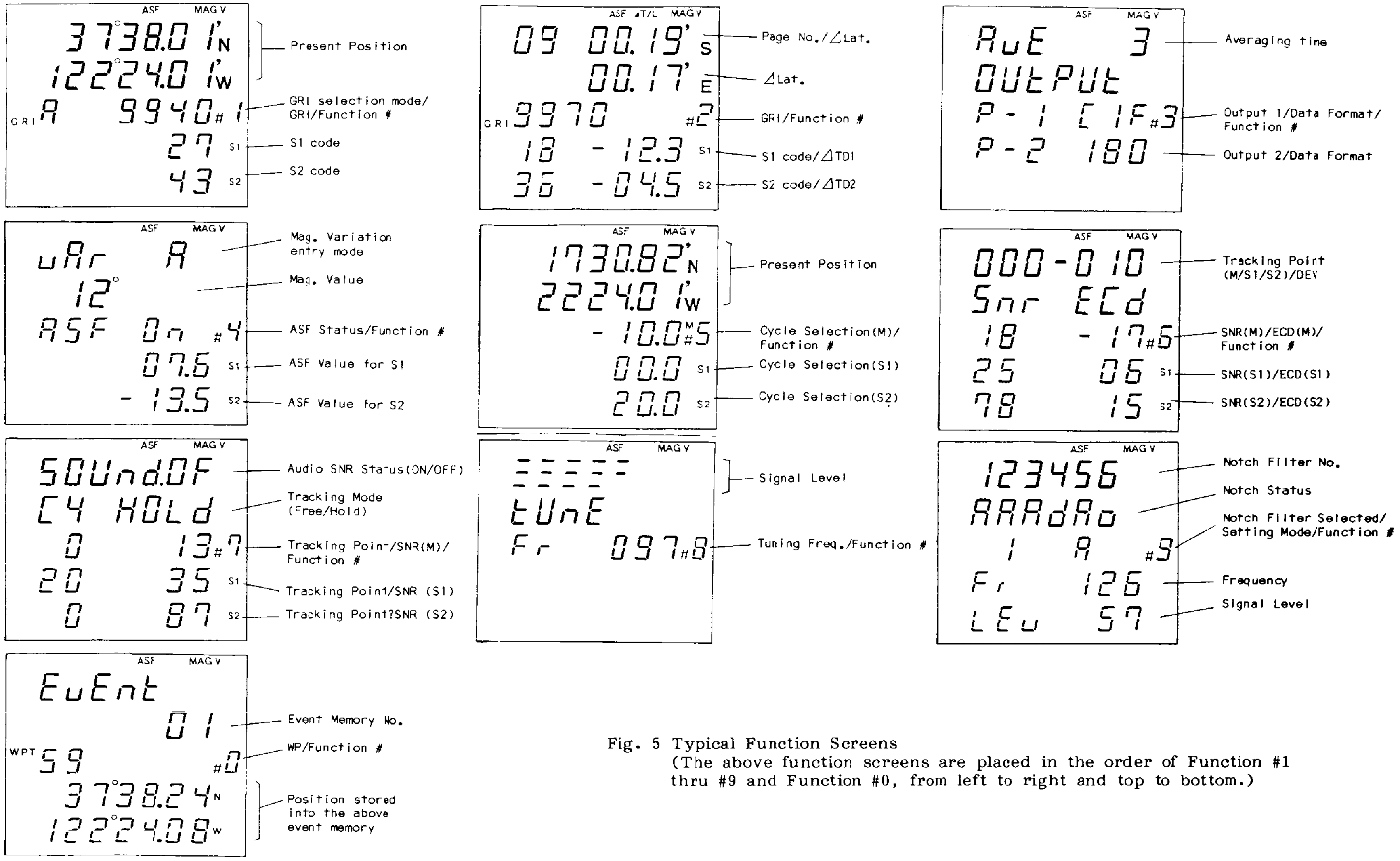


Fig. 5 Typical Function Screens
(The above function screens are placed in the order of Function #1 thru #9 and Function #0, from left to right and top to bottom.)

INSTALLATION

As was pointed out in the Introduction to this manual, this machine can only do its intended functions if it is installed properly.

GENERAL MOUNTING CONSIDERATIONS

The LC-90 consists of two units: the Display Unit and the Antenna Coupler Unit. The Antenna Coupler has been designed to withstand all the rigors of the marine environment, and if installed properly, is thoroughly waterproof.

The Display Unit is carefully constructed to be able to withstand the humidity and corrosive atmosphere common in a pilothouse, but it is not designed to be used outside, directly exposed to the environment! Salt water spray (or even coffee spills) will most assuredly cause damage to the sensitive components inside. Keep these factors in mind when planning the installation of the Display Unit.

Many owners will undoubtedly use the LC-90 on small boats, many with center consoles. The Display Unit must be mounted inside an enclosed cabinet, completely shielded from salt water spray, and from fresh water spray if the boat is usually hosed down after a day's outing. Corrosion can occur, especially on the rear connectors exposed to salt spray, unless these are taped and thoroughly sealed with putty compounds made especially for this purpose. Most small center console boats are equipped with such an enclosed cabinet behind the wheel, and most have clear doors so that equipment may be seen behind them.

FURUNO WILL ASSUME NO RESPONSIBILITY FOR CORROSION DAMAGE CAUSED BY EXPOSURE TO EITHER FRESH OR SALT WATER SPRAY!

The LC-90 consumes very little power, so there is no need for forced air ventilation. However it is necessary to provide at least some space behind and around the Display Unit to allow some circulation of cooling air and to provide convenient access to the rear connectors. If the Display is mounted in the center cabinet of a center console type of boat usually there is sufficient air movement to cool the unit properly.

Even though the LCD (Liquid Crystal) readout displays are quite legible even in bright sunlight, it is a good idea to keep the Display Unit out of direct sunlight or at least shaded because of heat that can build up inside the cabinet.

It is a regrettable fact of modern life that small attractive electronic gear seems to attract undue attention from thieves. In your installation planning it is a good idea to provide means either to hide the gear when you are not aboard or take the gear off the boat completely when you are finished for the day. Consideration should be made to provide space for access to the mounting hardware on the side and to the connectors behind the Display Unit.

DETAILED INSTALLATION INSTRUCTIONS

Antenna Coupler Unit Installation:

The antenna coupler unit is completely watertight when installed correctly. It should be mounted as high as possible on the boat, free from the influences of nearby antennas, rigging, and masts. Since it is rarely possible to avoid nearby metallic objects, especially on small boats, a compromise must be struck on most boats.

Most skippers prefer to have their VHF antenna on the highest mast because this is their primary means to signal a distress situation. The second most critical piece of electronics on the boat however should be the Loran-C antenna, and if this must be on the same mast as the VHF antenna, at least try to mount it on a crosstree on the other side of the mast from the VHF antenna. A separation between antennas of at least 3 feet is needed.

Loran-C antennas can perform adequately on sailboats with transom installations, but in marginal signal areas the performance may not be satisfactory. The presence of stays and other metallic rigging can cause the reception pattern to be somewhat more favorable in certain directions, instead of being omnidirectional like it should be. Obviously, it is a real nuisance to have to point the boat in a particular direction in order to find out where you are! There are many sailboat installations where an insulated stay works adequately but a separate whip antenna up in the clear is still preferable.

Antenna siting is not all science, but neither is it all "black magic" either. To determine the best location on your own boat it is suggested that you temporarily mount the antenna in a likely location and try it out. Later in this section the recommended test method will be given to determine if the installation site is OK.

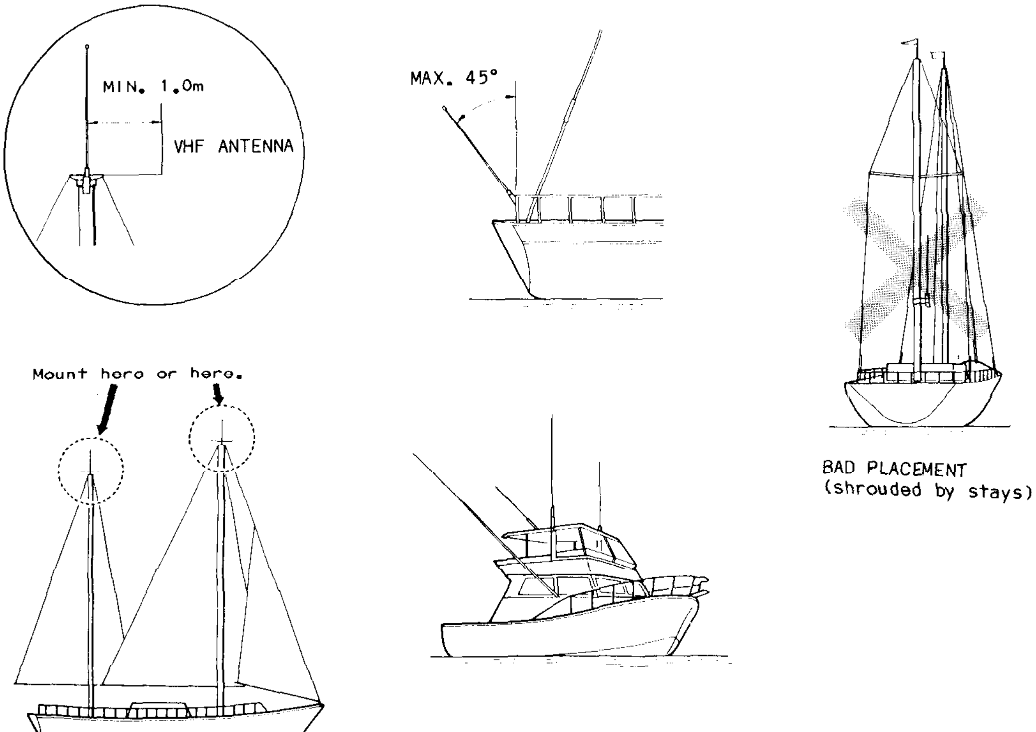


Fig. 6 Typical Antenna Placement

The Antenna Coupler uses a standard 96 inch fiberglass marine "CB" whip, which is screwed into the top fitting. (NOTE: so-called "loaded" whips which are much shorter than 96 inches are not suitable as a whip for the LC-90.)

The body of the Antenna Coupler can be mounted in two ways:

1. The bottom of the coupler is designed to accept a threaded extension mast (recommended height no longer than about 5 feet to prevent undue flexing of the mast in heavy winds). The thread should be 1 inch diameter, with a pitch of 14 threads per inch.

2. The side of the coupler has a molded channel so that it may be mounted directly to a stub mast with the two stainless steel hose clamps provided in the installation material. See the drawing below.

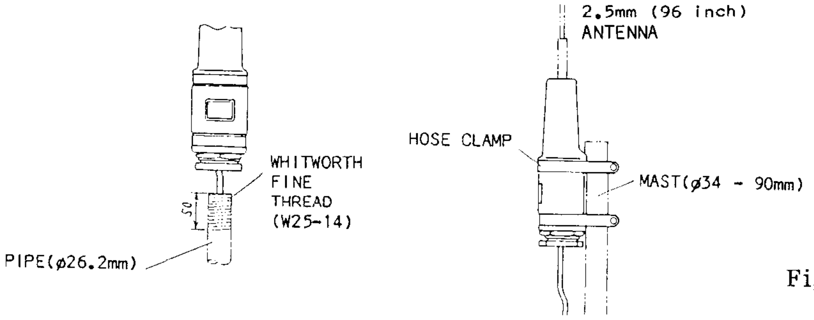


Fig. 7

The Antenna Coupler Unit comes with the interconnecting cable already prewired into it from the factory. You may however find it necessary to deal with the display end of the cable since the connector is supplied already wired to the display end. The connector may not fit through holes and wireways, and it may have to be removed and reinstalled later after the antenna cable has been routed through the boat.

When a 4m whip antenna (option-used in fringe reception areas) is used, its installation should be as in the drawing below. Note that the coupler is not designed to withstand the strain of such a large whip directly. Instead, a mounting plate for the 4m whip must be provided, with a wire to the antenna coupler from the bottom of the whip.

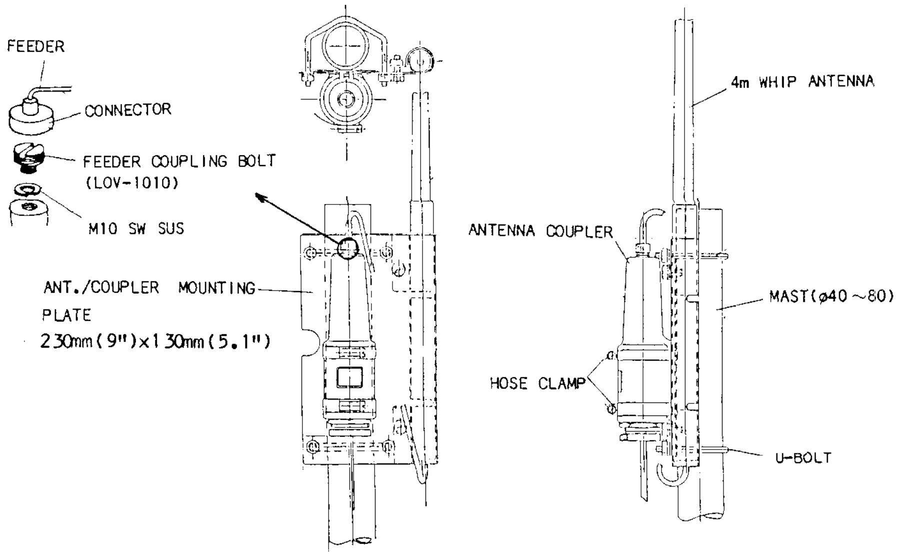


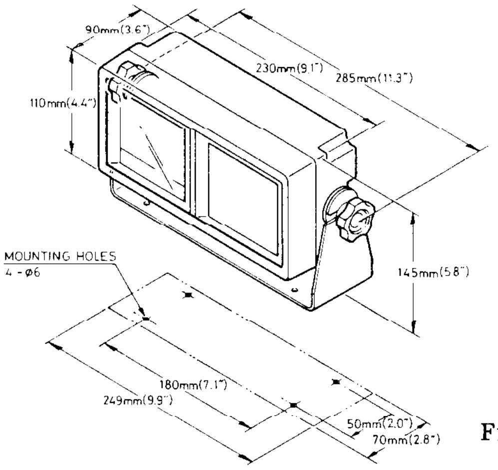
Fig. 8

Display Unit Installation:

Locate the Display Unit in a position where it can be viewed and operated conveniently but where there is no danger of salt or fresh water spray or immersion.

The Display Unit is mounted in a trunnion mount. The mount itself can be installed either overhead, on a bulkhead, or on a tabletop. The drawing below gives the recommended clearances and the mounting dimensions for this unit. You can use the mount itself as a template for locating the mounting bolt holes.

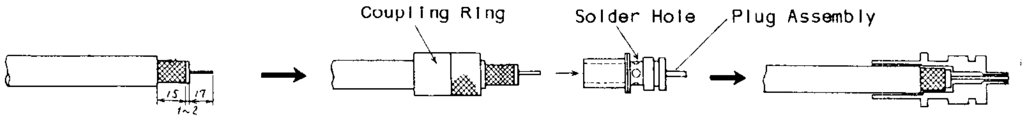
As was stated before, make sure you allow enough clearance both to get to the connectors behind the unit and to allow you to get your hands in on both sides to loosen or tighten the mounting knobs. Make sure you leave at least a foot or so of "service loop" of cables behind the unit so that it can be pulled forward for servicing or easy removal of the connectors.



Weight: 2.3kg

Fig. 9

If you find it necessary to remove the antenna connector that goes to the display, follow the directions in the drawing below. If you don't know how to solder or if you don't know how to do it well, it's best you leave this part to a competent service technician. In perhaps 50 percent of installation problems, poor soldering or wrong wiring of the connectors is where the problem lies. DO NOT SHORT ANTENNA CABLE!



Cut end of cable even. Remove vinyl jacket 34mm (1.34")-don't nick braid.

Bare 17mm(0.67") of center conductor-don't nick conductor. Trim braided shield 15mm (0.6") and tin. Slide coupling ring on cable.

Screw the plug assembly on cable. Solder plug assembly to braid through solder holes. Solder conductor to contact sleeve.

Fig. 10

Unless you are also installing optional peripheral equipment (such as a Track Plotter, autopilot or a Printer), the only wiring necessary is for the power connection and the antenna cable.

Power Connection:

Ship's power lines are notorious for being "dirty" electrically. The voltage can go all over the place as various heavy loads are placed on the line, and the power wiring is a prime source for interfering electrical signals (from such sources as alternators or generators, and other electronics equipment, like radars or echosounders.)

The LC-90 is a very forgiving machine since it has a built-in universal D.C. power supply that can take input voltages from 10 to 42 V.D.C. However, a piece of gear of this quality deserves to have a circuit breaker dedicated to it alone. The size of the wire feeding power to the unit should be no less than AWG 16 gauge (0.5 mm. square).

Ground Connection:

No less important for proper operation is the ground for the Display Unit. On a steel boat, a good connection to the hull is sufficient. On a wood or fiberglass boat, it is best to use a ground plate mounted on the hull exterior; if this is not practical the engine block can be used. Do not "share" ground leads that go to other equipment in the console, but instead run a separate heavy-duty wire for the LC-90 alone.

Follow the drawing below for detailed wiring information.

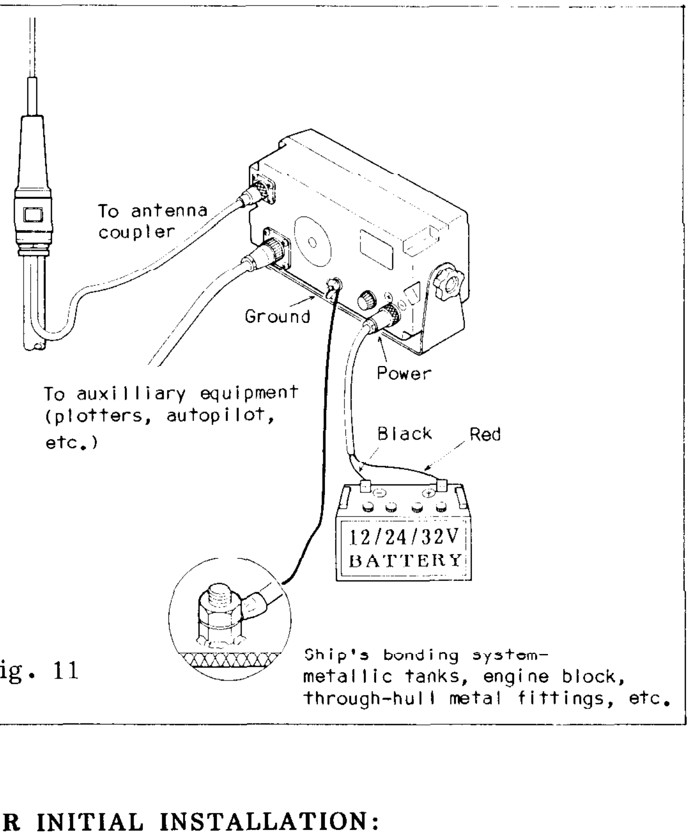


Fig. 11

TESTING AFTER INITIAL INSTALLATION:

The best way to check for the adequacy of an installation, and for the presence of noise aboard the boat which might hamper Loran-C reception,

is to use the "SNR" (Signal to Noise Ratio) function in the LC-90 itself. Make sure all electrical and electronic machinery on your boat is turned off before starting this test. This includes the engine and any auxiliaries as well.

Before plugging the power connector into the back of the LC-90, recheck the polarity of the DC using a voltmeter. Then plug the power connector into the back of the unit. Don't worry in the following procedure that you might not understand exactly what is going on: the details will be explained later in this manual. For now you just want to be sure that the installation is good enough and free enough from external interference so that you can run the LC-90 through its paces, and learn how to use it later.

1. Turn on the LC-90 by pressing the [PWR] key while simultaneously holding down the [CLR] key. This will clear the internal memory completely, and will allow the unit to initialize itself for your geographic area. Continue to hold the [CLR] key until two distinctive beeps of the buzzer are heard. The LC-90 will then automatically go into its Initialization function #1, and will be ready to accept the approximate Latitude of your present position. You must know and enter your latitude within a tolerance of one degree from the true position. For the sake of illustration, assume for now that you are located near San Francisco, and that your present position is approximately 37 degrees North latitude, and 122 degrees West longitude. Enter the following keystrokes:

   [CLR] [3] [7] [ENT] Entering initial Latitude, Function #1

   The flashing cursor will automatically advance to the longitude line, and here you would enter:

   [CLR] [1] [2] [2] [ENT] Entering initial Longitude, Function #1

Note: If your present location is in the Southern latitudes or the Eastern longitudes, you will need to override the default North and West hemispheric values by pressing the [+/-] key.

The cursor will automatically place itself on the next line, and the "A" on that line will flash. For now we will use the automatic GRI and slave selection function. Wait for less than approximately 120 seconds to see what the LC-90 decides as appropriate values. In our San Francisco example, the unit would automatically come up with a GRI of 9940, and with slave selections of 27 and 43. You needn't worry about what these numbers mean, at this point. Simply go on and leave Function #1 by hitting either the left or right arrow cursor keys.

Now press the left or right arrow cursor key until the indicator lines up over the "S/C" label. You should see displayed a screen similar to the one shown below.

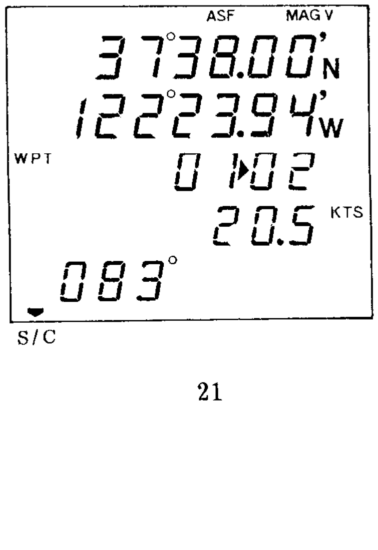


Fig. 12 S/C Mode Screen

2. You may wish to watch the receiver go through its acquisition sequence by hitting the [TD ↔ L/L] conversion key. You can now watch as the unit settles down on the correct TD values for your area. While the LC-90 is busy first identifying the master and slave signals, it will flash the MCYC, MSNR, SNR and CYC warning indicators. While it is acquiring and locking onto the signals, these warning indicators will stop flashing. When acquisition is complete (in about 3 to 5 minutes, depending on the quality of the Loran signals in your area) all signal warning indicators will extinguish, and the TD readout will be stable, with perhaps only the least significant digit to the right of the decimal point changing randomly up and down a small amount.

   Now call up the SNR function, the #6 Function, by first pressing the [#] key and then the [6] key. You should see a screen similar to the one below.

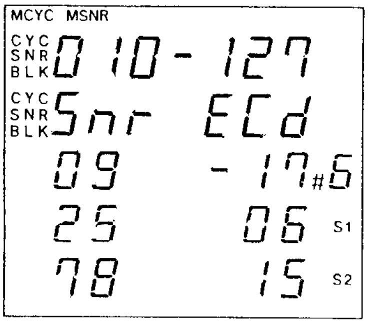


Fig. 13 Function #6 Screen

   The SNR for the Master and the two slave secondary stations automatically selected by the receiver are displayed on the left-hand side of the third, fourth and fifth lines respectively. The maximum value for SNR is "99," and unless you happen to be in a very strong signal area, it is likely that at least one of the stations being received will have an SNR value less than 99. It is important that you have at least one station whose SNR is less than 99 so that you can easily observe any small degradation of SNR as various interference sources on your boat are investigated one by one. If at least one station exhibits an SNR lower than 99, you may proceed to step 4. below. Before doing that however, write down the SNR values for the three stations, preferably in the back of this book so that you will have a permanent record of SNR values. Otherwise, go to step 3. below first.

3. In the extremely unlikely situation where all three stations have SNR's of 99, go back to function #1 by pressing the [#] key followed by the [1] key. Look in the appendix at the back of this book for the chart that describes your geographic area. You will note that any particular area has two slave secondaries associated with it that are the optimum choices. However, most Loran chains have other secondary stations available that do not represent optimum choices, usually because they are far removed from that area, and thus would be rather weak in signal strength. In the case of our San Francisco example, the optimum slave secondaries are the "27" and the "43" secondaries. However there is a third secondary station in the chain: the "11" station, and it is located in Washington state, far from the San Francisco area and hence probably rather weak. Again, you shouldn't worry at this point that you may not know exactly what these mysterious numbers mean, just note the two-digit value of the other secondary stations that the Loran chain is capable of providing in your own area of operation.

Going back to our example, if the Master and the two optimum secondaries happened to be exhibiting SNR's of 99, then we might select the "11" station to observe in order to evaluate subtle changes in SNR readings due to interference from other sources on the boat.

Make sure you are in Function #1. Move down to the third line, using the down arrow ▼ cursor. Hit [CLR], and then hit the [+/-] key, followed by [ENT] to change the "A" to "d," disabling the Automatic Selection process. Move the cursor with the ▼ down arrow down to the fourth line, hit [CLR] [1] [1] [ENT]. Now go back to function #6, by hitting the [#] key and then the [6] key. Observe the SNR of the weakest station, and write the numbers for all three stations down in the back of this manual. Now you can proceed to step 4 below.

4. Now, turn on the other electronics on the boat (radar, echosounder, etc.) one at a time and observe the SNR readings over a period of several minutes. Make sure you operate the other equipment in all possible modes. For example, make sure that the radar is used in both standby and then transmit modes, with the scanner turning and turned off, etc. Write down the resulting SNR's for each piece of gear, and then shut it off and do the next piece of equipment. If the SNR reading drops from, say, 90 to 85, then you are probably OK, but if it drops from 90 to 60 or lower, you have a definite interference problem that a qualified electronics technician is going to have to fix before you can obtain proper Loran-C performance. Your written record of SNR values will be helpful to him.

If you are quite fortunate you will find that no other piece of electronics on board your boat interferes badly with your new Loran-C. Assuming that your luck is with you and that this is indeed the case, let's go on to test a device that in at least 90 percent of Loran-C installations does cause an interference problem: the alternator.

There are several technical reasons why alternators seem to be antagonistic toward Loran-C receivers, but going into the why's and wherefore's isn't as important as figuring out how to cure the little beast of this nasty habit. Start your engine and increase engine speed until your charging ammeter goes upscale. You will probably now notice that the SNR indication of your Loran-C begins to plummet.

Not all alternators respond to interference-removal techniques in the same manner. Some alternators, it is sad to say, cannot be suppressed at all, and these must be replaced or rebuilt if you wish to have useable Loran-C operation. Don't blame the Loran-C receiver! It is a sensitive instrument, and it is simply responding to the noise broadcast by the alternator.

The first step to take when alternator noise is discovered is to try a large electrolytic capacitor mounted right at the output terminals of the alternator. The capacitor must be rated for the nominal output voltage of the alternator, plus a 50% safety factor. For example, if the alternator is a nominal 32 V.D.C. unit, you should use a capacitor rated for no less than 32 + 32/2, or 48 Volts. A 50 V.D.C. unit should suffice.

This capacitor should be a "computer-grade" unit, that has internal vents in case it should overheat and possibly explode, and the capacity of the electrolytic capacitor should be about 10,000 microfarads or so. Be careful to observe the polarity of the capacitor. Reverse polarity will destroy the capacitor, and could damage the charging system as well. The positive lead

of the capacitor is connected with a short lead (less than 4 inches long) to the Output terminal of the alternator, using a large crimp lug to go under the terminal, in parallel with the heavy lead going to the battery bank.

The negative terminal of the capacitor should go to a mounting bolt used to secure the alternator to its mounting frame. This lead also must be kept shorter than 4 inches or so in order for the capacitor to do its job.

Do Not connect the capacitor to the Field terminal of the alternator, at the risk of destroying the alternator itself.

Hopefully, the electrolytic capacitor will do the job for you, and if that is the case you can proceed to mount it securely to the alternator, perhaps by using "tie-wraps". Make sure the capacitor isn't able to move around under vibration, since the leads could be broken off.

If you have any doubts about what you are doing, it is time to call in a qualified electronics technician, especially if the simple capacitor treatment doesn't do the trick.

Color TV's: One other particularly nasty interference source is the typical home-grade color television, although sometimes a regular black and white TV will wreak havoc on Loran-C reception. Unfortunately, the only solution to this sort of interference is to turn the offending TV off, or else purchase a commercial grade TV receiver which is better shielded than the home-quality units.

HOW TO COMBINE WITH AUXILIARY EQUIPMENT

The LC-90 provides a data output connector on the back panel. This is used for connection to peripheral equipment, such as a position plotter, a printer, or an autopilot.

Position data is sent outside the LC-90 in one of several different data formats:

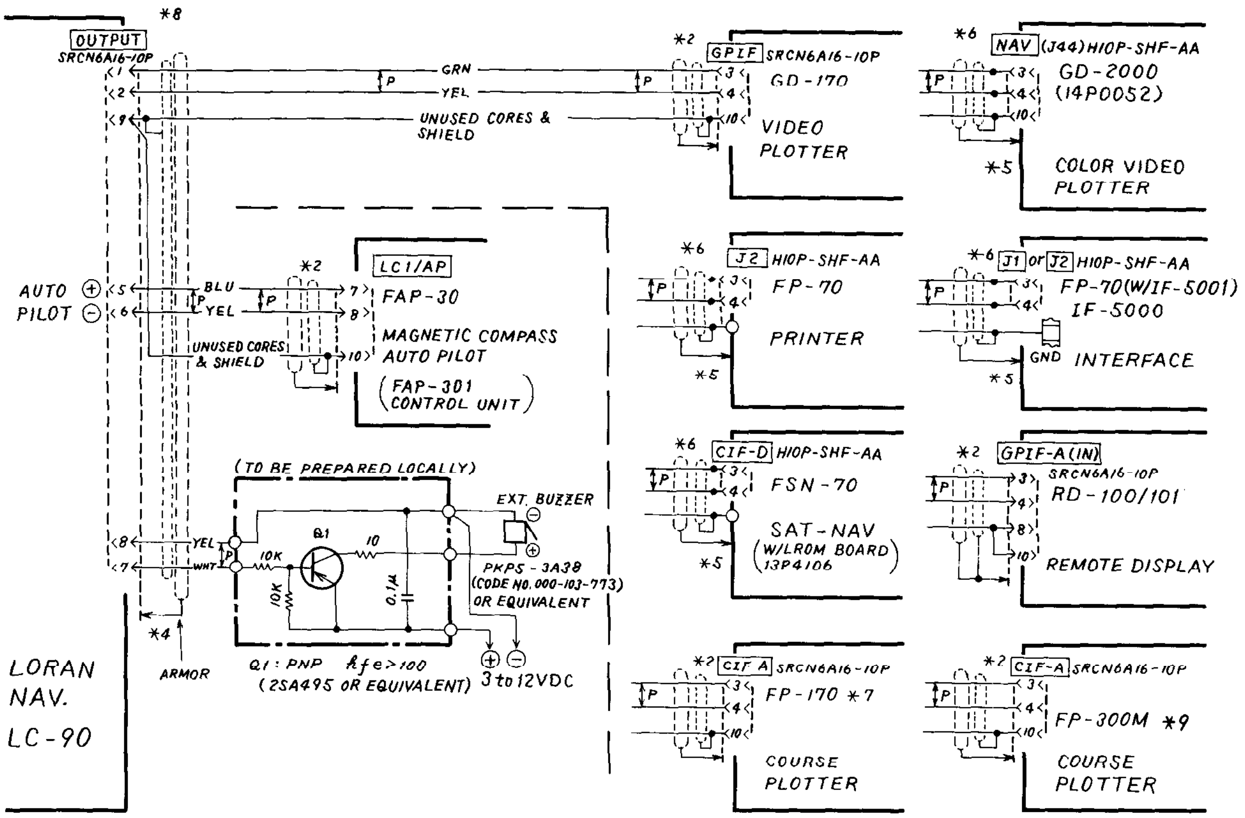
a. Furuno CIF (Computer InterFace) for Furuno peripherals.

b. NMEA 0183 Complex Format, for plotters.

c. NMEA 0180 Simple Format, for Autopilots.

An optional connector cable kit (LC-1091 -- Furuno Code No. 000-041-156) is needed to access the output data.

The interconnection diagram is shown on the next page.



NOTE

*1. USE CABLE CO-SPEVV-SB-C 0.2×5P.	*6. 15cm LEAD WIRES FITTED. SOLDER IN FIELD. CUT UNUSED WIRES.
*2. CONNECTOR PLUG FACTORY-WIRED.	
*3. P TWIST PAIR.	*7. LOP'S LINES NOT PLOTTED.
*4. GROUND ARMOR THRU CONNECTOR CLAMP.	*8. CONNECTORS NOT SUPPLIED AS STANDARD.
*5. GROUND THRU CABLE CLAMP.	*9. LOP'S & L/L PLOTTED.

Fig. 14 INTERCONNECTING DIAGRAM FOR LORAN-C NAVIGATOR LC-90 ↔ PERIPHERAL EQUIPMENT

BASIC LEVEL OPERATIONS

TURNING THE UNIT ON AND OFF

Press the [PWR] key. After several seconds (during which time the LC-90 will be performing an internal self-check) the display will activate. If an error should be detected during the self-check sequence, an error message will be displayed on the screen. Details for the meanings for these error messages are described in the Troubleshooting Section.

To turn the LC-90 off you must press both the [PWR] and [OFF] keys simultaneously. This specific sequence is necessary in order to prevent you from inadvertently turning off the unit by accidently pressing the [PWR] key. If this were to happen you would have to wait another five minutes or so after power is turned on again while the unit acquires and locks onto the signals.

INITIALIZING THE NAVIGATOR FOR YOUR OWN GEOGRAPHICAL AREA

The LC-90 is designed to retain in memory all information necessary for operation whether it is turned on or off. An internal "keep-alive" battery performs this function. Once the LC-90 has been initialized for your area, you need do nothing more than turn the power back on when you want to set out on a new voyage.

As "smart" a unit as the LC-90 is, it still needs to know approximately where it is located in order for it to home in on the correct Loran signals for that area. Thus the first time you use the unit you must initialize it for your geographic area. From then on, unless you wish to override its automatic selections, the unit will determine the exact position automatically. You must enter your approximate location within about +/- 3 degrees, although you may have to be more accurate than that if you are located in an area close to a baseline extension. In this case the unit requires a starting location within about 1 degree of the actual location.

Similarly, if you move the LC-90 more than about 60 miles (approximately 1 degree in latitude) with the power off you will need to reestablish the approximate starting position. Before you start operation, obtain a Navigation Chart for your area, preferably one with Loran-C TD lines overprinted on it. Keep this chart nearby as you go through the various procedures so that you can verify that the LC-90 is giving you reliable and sensible numbers.

Clearing the Memory:

The very first time you turn on your new unit, you will have to clear the internal memory to ensure that no stray data has been stored there. Make very sure that you want to clear the memory completely before you do this: all information, including waypoints that you may want to keep, will be lost after this operation!

Make sure the LC-90 is turned off first, and then hold down the [CLR] touchpad while pressing the [PWR] key. Hold the [CLR] key down until you hear two beeps, and then you may release it.

Initializing Latitude/Longitude (Function #1):

After the memory has been cleared (or after you call up Function #1), you will find the cursor on the latitude line. After clearing memory you will find

that the line is full of dashes. (After hitting the [CLR] button after calling up Function #1 you will find the line full of dashes.) Enter your approximate latitude. Assume for sake of illustration that you are in San Francisco, and that the approximate location is 37 degrees North latitude and 122 degrees West longitude. The sequence of keystrokes to enter this information would be:

[CLR] [3] [7] [ENT] 37°00.00' N Latitude.

Note that the entry of trailing zeroes is optional. For example, you could have entered the full latitude of "370000" rather than the short-form "37" if you wanted to. The cursor will automatically move down to the next line, where you will enter the longitude. The keystrokes for this operation are:

[CLR] [1] [2] [2] [ENT] 122°00.00' W Longitude.

Note that if the longitude were for example, 22 degrees North, you would have to enter the leading zero:

[CLR] [0] [2] [2] [ENT] 022°00.00' N Latitude.

Note also that the default values for latitude is North latitude and West longitude. If you are in the Southern latitudes or Easterly longitudes, you will need to override the default hemispheric values by using the [+/-] key. For example, if you are located in Osaka, Japan, at 34 degrees North latitude and 135 degrees East longitude, you would enter:

[CLR] [3] [4] [ENT] 34°00.00' N Latitude.

[CLR] [1] [3] [5] [+/-] [ENT] 135°00.00' E Longitude.

Now you should find that the cursor has automatically moved to the third line, and that the "A" on that line is flashing. This gives you the opportunity to Disable the "Automatic" selection of GRI and the two slave secondaries. At this time we suggest that you let the LC-90 automatically select these values. In a later section of this manual you will learn the procedure to Disable the automatic process.

Now the LC-90 will begin searching for the master and slave stations to verify the present approximate position you just entered. The display will show "9999" for the GRI, and "99" for both slave stations. The "MCYC," "MSNR," "SNR" and "CYC" signal warning indicators will flash at this time. After about a minute, these warning indicators will cease flashing, and the appropriate GRI and slave secondary TD numbers will appear on the fourth and fifth lines. A typical Function #1 is shown below.

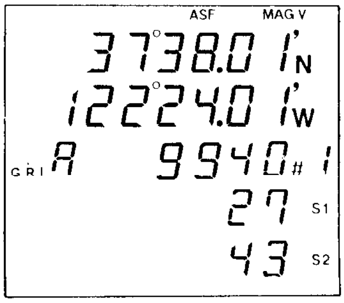


Fig. 15 Function #1 Screen

Note that the secondary stations are represented by the first two digits of the appropriate number of microseconds. You may wish to look in the Appendix A in the back of this manual to assure yourself that the unit has chosen the correct GRI and slaves for your area.

You should now go back to the S/C Mode to observe the receiver while it is locking onto the Loran signals. Press either the ◀ or the ▶ left or right arrow key to exit Function #1, and then press either one of these keys until the Mode indicator arrow is lined up over the "S/C" label on the front panel under the display. Now, press the [TD ↔ L/L] key to watch the TD's change while the unit is locking onto the Loran signals.

After acquisition and locking is complete all the signal warning indicators will be extinguished, and the TD readings will be stable. You must always remember that the unit is not ready for navigation until these signal warning indicators are extinguished. These indicators will be fully explained in a later section of this manual.

The acquisition process will take between three and five minutes, depending on the quality of the Loran signals in your area. Switch to the Latitude/Longitude display by pressing the [TD ↔ L/L] key again. Note that the L/L readout is stable, and that your position is displayed in degrees, minutes and tenths of minutes (not seconds!). Check the LC-90's position with that shown on your chart. It normally should be reasonably close, but while you are in port the position may be as far off as a quarter mile or so because of signal distortion caused by passage of the signals over land nearby. Don't worry: things will get more accurate once you are out of harbor.

However, it is still a good idea to check your TD numbers against those from a nearby vessel and with your chart to ensure that the unit has locked onto the correct point of the slaves and the master signals, and that no strange things have occurred during the acquisition process. It is well to remember that the TD lattice printed on a Loran-C chart is adjusted before printing to compensate for warping of the grid because of ASF (Additional Secondary Factors), and that TD's plotted on such a chart are thus inherently more accurate than the Latitude/Longitude calculated from TD's. In other words, TD's are observed phenomena, and Latitude/Longitude numbers are derived mathematically from this observed data.

READING SPEED AND COURSE (S/C Mode)

Verify that the Mode indicator arrow is lined up over the "S/C" label. It will take a minute or two after the receiver has finished its acquisition process, but you will eventually see the display showing the Speed Made Good and Course Made Good. Of course, if you are presently at the dock, the speed should be close to zero, and the course will randomly vary around the compass rose.

Note: this function as well as many others will only work after the receiver has completed the acquisition process and after all warning indications have been extinguished.

The Speed Made Good is defined as the speed over ground, and is calibrated in knots. The Course Made Good is referenced to Magnetic North whenever the MAGV label is shown in the upper right-hand side of the display. The amount of Magnetic Variation is automatically calculated by the LC-90 for the your geographic area. You may at this time wish to look at the amount of

magnetic variation presently being used. This can be done by accessing Function #4. Press the [#] key, followed by the [4] key. A typical display is shown in Fig. 16. The label "vAr" in the top line of the refers to "Magnetic Variation," and the "A" shown refers to "Auto," indicating that the variation is applied automatically.

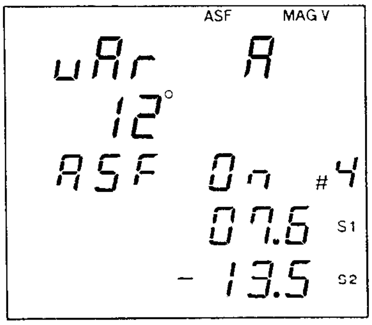


Fig. 16 Function #4 Screen

The preprogrammed magnetic variation values are the average of those in the area of approximately 10 degrees by 10 degrees. Although the preprogrammed variation should be more than accurate enough for most purposes, if a more accurate variation is needed, enter it manually, using the following procedure.

Manual Entry of Magnetic Variation (Function #4):

1. Verify that the unit is in Function #4.

2. Press [CLR]. The "A" will change to a dash next to the label "VAR" on the top line.

3. Press [+/-] and then [ENT]. You will see the "A" change to a "d," indicating that the Automatic mode has been Disabled. Now the unit has been placed in manual magnetic variation mode. The cursor will automatically advance to the next line.

4. Type in the desired magnetic variation, followed by [ENT]. For example, if the magnetic variation for your area is 12 degrees West, the keystroke sequence would be [CLR] [1] [2] [ENT]. If however the magnetic variation is 12 degrees East, then the sequence would be [CLR] [+/-] [1] [2] [ENT], since the default (+) value, standing for West variation, must be overridden. The MAGV indicator at the top of the display will be on whenever Magnetic bearings are in use.

True Bearings (rather than Magnetic Bearings) (Function #4):

If you would rather have the LC-90 display bearing in True (relative to True North rather than magnetic north), this can be accomplished by setting the magnetic variation in the Disable automatic mode to be zero degrees. Verify that the LC-90 is in Function #4, and then select the "d" mode using the [+/-] key. Move the cursor down to the second line and type in 00 for the variation. The entire sequence is:

[#] [4] [CLR] [+/-] [ENT] [CLR] [0] [0] [ENT] True North bearings.

The MAGV indicator at the top of the display will disappear.

SETTING THE AVERAGING TIME (Function #3)

If you are still presently sitting at the dock while you are learning the operation of your new Loran-C navigator, you may note that the speed reading varies a bit, in a random fashion. This is a function of several factors, most noteworthy being the strength of the incoming Loran-C signals and the minute random variations of the propagation path between you and the transmitting station.

The calculation of speed is sensitive to these random variations, especially at low speeds. You may smooth out excessive speed fluctuations by specifying an "averaging" time constant that in essence lengthens the time interval over which the calculation is done. The tradeoff for a less-jittery speed readout is that sudden changes in speed (actual acceleration or deceleration of the boat) take longer to show up on the S/C readout. In general, an Averaging time constant of 1 to 4 is a practical value for most people, but you may want to experiment some with the value that most suits you.

It should be noted that the Averaging time constant will affect the speed that the Latitude/Longitude readout changes as well as the Speed readout, but that the TD readout will not be affected. To change the Averaging constant access Function #3. The amount presently used will be shown on the first line, to the right of the label "AvE." To enter an averaging constant of 4 you would use the following keystroke sequence:

[CLR] [4] [ENT] Entering Averaging constant of "4."

For the time being don't worry about the other lines on the display. We'll get into those subjects later.

AUTOMATIC ASF (Function #4)

You will remember that in the Elementary Theory Section that we said that the LC-90 has a built-in capability of using TD offsets to compensate for warpage of the TD grid occurring due to ASF (Additional Secondary Factors) caused by propagation of the Loran signals over part-land, part-sea paths. This automatic ASF compensation will yield better accuracy of the calculated Latitude/Longitude than will the raw calculation using uncompensated TD numbers.

When the LC-90 is first used after the memory has been cleared, the default setting for automatic ASF compensation is "off." For most operations using latitude/longitude it is desirable to have the automatic compensation engaged all the time. Only when TD numbers (perhaps from a fishing buddy or your own old records from another Loran-C receiver) are used will it be necessary to disable automatic ASF compensation.

The LC-90 contains a built-in table of ASF compensation values for geographic areas where these warpages have been measured by the U.S. and Canadian Coast Guards, but other areas of the world have not been measured as of this time. To activate the automatic ASF compensation, you must call up the Function #4 by first typing [#] followed by [4]. As with all the Functions it isn't necessary to use the [ENT] key after typing in the [4].

You should now see a screen similar to the one in Fig. 16, where the cursor will be on the "A," since it is flashing. This is the Automatic Variation function. You will need to hit the down arrow key twice, and hit [CLR]

followed by [+/-]. You should see the "OFF" indication next to the label "ASF" change to "On." If your geographic area is one of those that have ASF compensation values tabulated for it, after less than about 2 minutes of computations, you will see the values of TD offsets that will now automatically be factored into the L/L computations. If your area doesn't have any ASF compensation values available, the "ASF" indicator that has now appeared on the top of the display will blink. Otherwise this indicator will be steady, indicating that automatic ASF compensation is in effect.

Note that the ASF compensation values programmed into the LC-90 are the average values for a 1 degree by 1 degree grid. If for some reason you need more accurate compensation values, you will have to enter these manually. This procedure will be covered in the Advanced Level Operation section later in this manual.

Meanwhile, go back to any of the Modes showing present position (Modes S/C, VTD, R/B, XTE, WPT, CLC and ALM) to see your present position. Compare this indicated position to that on your chart, and you should see that it compares more closely than it did before ASF compensation was applied.

DIMMER

The backlighting illumination level for the display and the keyboard may be varied in four different levels of intensity: bright, medium, dim and off. Press the [DIM] key four times to change the level in this sequence.

SUMMARY OF BASIC OPERATIONS:

If you have faithfully read this far, you will find that you have mastered the basics necessary to use your LC-90. You now know the following:

- You know how to enter your approximate location in Latitude/Longitude for initialization of the unit.
- You know that if you stay in the same general area after the unit has once been initialized that all you have to do at the start of a new day is turn the power on to the LC-90.
- You know how to read your position in both L/L and TD's.
- You know how to reduce jittery speed or L/L readings with the Averaging function.
- You know how to apply automatic ASF compensation for more accurate L/L computations.
- You know how to adjust the level of illumination of the readout and the keyboard.

In fact, you know quite a bit about the LC-90 and how to use it.

The next section will go deeper into more of the quite incredible things that the LC-90 can do for you.

INTERMEDIATE LEVEL OPERATIONS

In this section we will start dealing with functions that will allow you to plan, and then actually make, voyages to destinations of your choice. You may wish to go to a specific position such as a particular buoy, or you may wish to return to a place where the fishing was good previously.

If you are a commercial fisherman you may want to go back to an area where you know where the "hangs" (net hang-ups) are so that you may be able to avoid them and not tear up your nets.

ENTRY OF A POSITION INTO A WAYPOINT (WPT Mode)

In Navigation terminology, a particular location is known as a "Waypoint," whether it be a starting point, a destination point or an intermediate point on a voyage.

The LC-90 is capable of waypoint entry by four different methods:

a. By Latitude and Longitude coordinates of a location.

b. By TD's (Time Differences) of a location.

c. By using the [EVT] button to store present position in a waypoint.

d. By Range and Bearing from your present position.

In the early days of Loran-C technology many people became quite accustomed to the use of TD's; after all, TD-only receivers were the only ones available at reasonable prices. Many commercial fishermen especially developed an extensive list of TD's where they had experienced either good fishing or had encountered "hangs."

Modern receivers, with their ability to use Latitude/Longitude directly, are easier to use for most people since all navigation charts are printed with Latitude and Longitude coordinates, and only a relatively few charts are available with Loran-C TD overlays.

Many commercial fishermen with their hang logs in TD's will find that it is a good idea to write down the corresponding Latitude/Longitude coordinates next to their older TD information when they make a TD to L/L conversion while entering specific positions as waypoints. (See the Advanced Level Operation section for a tip on how to enter TD's as waypoints, while still retaining the advantages of automatic ASF compensation.) The other methods will be used during a voyage, when you want to record an interesting place instantly, such as for example a good fishing spot you happen across.

Now before you actually start punching in numbers, take a chart of your area and choose a buoy or some other position you know and write down on a scratchpad the Latitude and Longitude coordinates for your waypoint.

Using a divider, measure the distance from your present position to your waypoint, and then write that down. Now measure the magnetic bearing from your present position to your chosen waypoint using parallel rulers and write that information down. What we will be doing is comparing the numbers you have derived for Range and Bearing with those from the LC-90.

Waypoint Entry By Latitude/Longitude Coordinates (WPT Mode):

Entry of a position into a waypoint is a two-step process. First you assign a number to identify a particular waypoint, and then you enter the desired position into that waypoint.

The LC-90 has one hundred waypoints into which position information may be entered. These are numbered from "zero-zero" to ninety-nine. The LC-90 allows you to look at the position already stored in each numbered waypoint by specifying the waypoint and then using either the L/L or the TD format to read the stored position.

Some people might search through the waypoints already stored in the unit in order to find an empty waypoint in which to insert new information. However, it is probably less confusing to insert data sequentially, starting at waypoint one and proceeding upwards, one by one, in the sequence that the waypoints will actually be encountered on the voyage. Obviously, it's important that you write down your voyage plan in your log so that you have a permanent record of which waypoint is which.

Some operators prefer to reserve Waypoint ninety-nine as a sort of "scratchpad," so that any interesting position information they might for instance hear on the radio may be entered at the moment it is heard. Any position data that have been stored in other waypoints thus will not be disturbed, or even lost, in the heat of the moment. Waypoint "00" is a special one. It is reserved for use when your present location is used in a navigation calculation. This will be explored in more detail later.

Conceptually, waypoints are best thought of as being "Waypoints From" a desired origin or as "Waypoints To" a desired destination. Several navigation functions that will often be used in planning voyages make this distinction between "From" and "To," even though any one particular waypoint may be used for either purpose, since each waypoint defines a specific location on earth, whether you want to go towards it or away from it.

Let us assume for purposes of illustration that we wish to enter the Latitude and Longitude position of San Francisco into Waypoint Zero Seven. The coordinates are: 37 degrees, 40.00 minutes North Latitude, and 122 degrees, 24.00 minutes West Longitude. You would of course enter your own approximate L/L coordinates. The sequence of keypunch operations would be as follows:

1. Move the right arrow key until the Mode indicator arrow is directly over the "WPT" label on the front panel beneath the display. Observe the waypoint number in use there now. The waypoint number is located on the third line next to the "WPT" label. The first digit of the waypoint number will be flashing to indicate that the data-entry cursor is presently at this location. The latitude and longitude of the waypoint in use at this time are displayed on lines four and five of the display. If you want to see the TD's that correspond to the L/L for this waypoint, hit the [TD↔L/L] key. Hit the key again to get back to the L/L readout.

   Note: if the L/L is zero degrees latitude and longitude in a waypoint, the corresponding TD's will be non-zero values representing the TD's that would be present at zero latitude, zero longitude. The exact value of these TD's will change depending on the GRI in use by the LC-90 at that moment. The important thing to remember is that the LC-90 stores positions in L/L format in its waypoint memory, and that an L/L position

of zero/zero degrees indicates that the waypoint is empty.

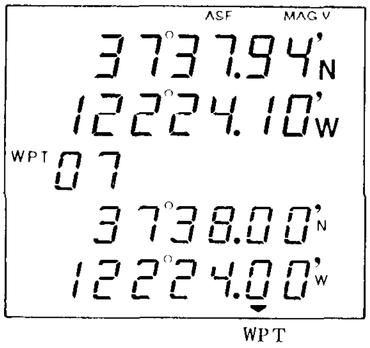


Fig. 17 WPT Mode Screen

2. Now respecify the waypoint to be waypoint zero seven. Use the following touchpad sequence:

   [CLR] [0] [7] [ENT]

   Note that the entry of the leading zero is necessary. Entering "7" after [CLR] will simply cause the LC-90 to ignore the input as invalid. If waypoint zero seven is presently empty, you will see zeroes on lines four and five. Now go ahead and enter the San Francisco numbers, as the cursor has automatically advanced to the next line after you hit [ENT] .

3. [CLR] [3] [7] [3] [8] [ENT] 37°38.00' N

   [CLR] [1] [2] [2] [2] [4] [ENT] 122°24.00' W

   Note that the entry of trailing zeroes is optional. The LC-90 senses when trailing zeroes are necessary and adds them as needed. Now you may hit the [TD ↔ L/L] key to see what TD's correspond to the L/L you just entered. Note also that if we were operating in Southern Latitudes and Easterly Longitudes we would have to override the North and West defaults that the LC-90 has been normally set up to use. For example, if the position of our Waypoint zero seven were 37 degrees, 40.00 minutes South Latitude, and 122 degrees, 24.00 minutes East Longitude, we would punch in the following sequence.

   [CLR] [3] [7] [3] [8] [+/-] [ENT] 37°38.00' S

   [CLR] [1] [2] [2] [2] [4] [+/-] [ENT] 122°24.00' E

Waypoint Entry By TD's (WPT Mode):

The second method of specifying a waypoint position is by TD's. This process involves converting the TD's to appropriate Latitude/Longitude coordinates and then using those coordinates for the waypoint. This sounds like an involved process, but the LC 90 makes it straightforward, provided that the operator uses some degree of caution.

Back in the section on How Loran-C Works we stated that Loran-C TD's form hyperbolic shaped lines and showed a simplified drawing (Fig. 18). We have reproduced that figure here to refresh your memory.

You will note that these umbrella-shaped lines are symmetrical about the baseline between the master and slave transmitting station. You might think of the baseline as a mirror, where a TD line of position on one side has a mirror-image on the other side of the line.

While it is true that for a particular Latitude/Longitude position there is at least one set of two TD's that cross at that point, it is also true that for any one set of two TD numbers there are two Latitude/Longitude positions.

You'll probably have to think about that one for a while and look closely at the drawing.

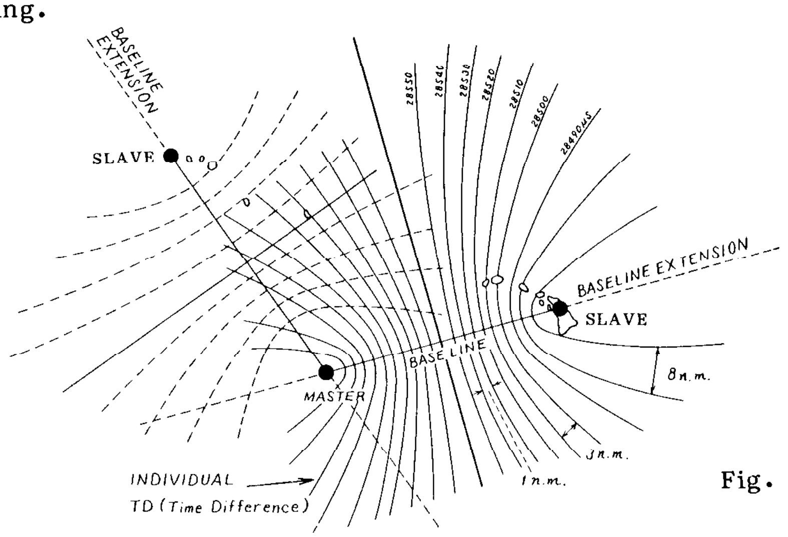


Fig. 18

What it all boils down to is that in order to convert a set of two TD's to a set of Latitude/Longitude coordinates, you have got to be on the correct side of the baseline (and its associated "baseline extension," where the baseline between the master and slave station is extended on through past the slave.) Without all the jargon, the TD's for the position you want to put into a waypoint must be within about one hundred miles or so of your present position in order to use the TD to L/L conversion, and they shouldn't be on the opposite side of a baseline extension from your present position. It is a good idea to plot the resulting L/L reading that the LC-90 comes up with in making the conversion between TD's and L/L on a chart to see if the calculated position makes sense to you.

Let us use the following numbers as an example. The GRI in use is 9940, and the Slave stations in use are the "11" and the "27" lines. We assume here that LC-90 has already locked onto the signals, and that the desired TD's are relatively close by -- for example, they may have been sent to you over the VHF radio by a fishing buddy. The TD's to be converted are: 12885.0 and 27932.4 microseconds. The approximate Latitude/Longitude at these TD's is 44 degrees, 30 minutes North Latitude, and 124 degrees, zero minutes West Longitude.

(Note that the slave stations that the LC-90 is presently tracking should be the same as the TD's you want to use to make the conversion between TD's and Latitude and Longitude, and it is necessary for the GRI in actual use to be the same as the one that was originally used for generating the TD's you want to enter.)

Another important point: if the automatic ASF compensation function is activated (as recommended for most operations), and if you wish to convert

from TD's to L/L, the ASF function must be disabled. If you don't do this you will be in effect counting the ASF twice, and any Range/Bearing readings to the resulting waypoint will be inaccurate. In the section on Advanced Level Operations we will describe the operations to use in order to employ more fully the benefits of the automatic ASF compensation capabilities of the LC-90, even when using TD's to enter a position. You can disable the automatic ASF compensation function using Function #4.

The sequence of operations is:

1. Call up Function #4 and disable the ASF Auto function, if it is on. The keystroke sequence is as follows:

   [#] [4] [▼] [▼] [CLR] [+/-] [ENT]

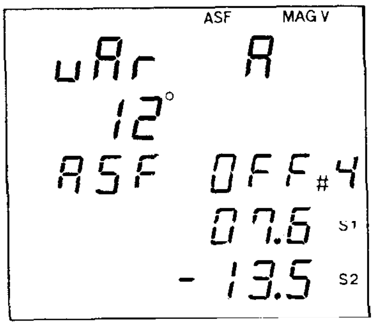


Fig. 19 Function #4 Screen

2. Call up the WPT Function by moving the left or right arrow key until the Mode indicator arrow is lined up directly over the "WPT" label on the panel under the display. Specify the waypoint number into which you wish to store the TD information (we'll use waypoint zero eight here), and then enter the desired information. The following touchpad sequence would be used:

   [CLR] [0] [8] [ENT] [TD↔L/L] [1] [2] [8] [8] [5] [0] [ENT]

   [CLR] [2] [7] [9] [3] [2] [4] [ENT]

3. Now switch back to the L/L display to see the resulting L/L. You must wait for the L/L display to settle down with all numbers and indications stable before proceeding on to any other Mode or Function.

Waypoint Entry of Present Position ([EVT] key in WPT Mode:):

There are times when you will want to store your present location into a waypoint. For example, you might have come across a particularly good fishing spot, and want to record it as a waypoint so that you may return to this location at a later date. The procedure is simple: first, make sure that you are in the L/L format, and then get into the WPT Mode. Then specify the waypoint number into which you want to store the present location.

Now, hit the [EVT] key.

You will find your position has now automatically been stored into the waypoint. Obviously, this requires some caution on your part. The infor-

mation stored in a waypoint will be overwritten when you press the [EVT] key. Check to make sure that an existing waypoint is empty before hitting the [EVT] key, unless you don't mind losing old information.

Waypoint Entry by Range/Bearing From Present Position (CLC Mode):

The LC-90 provides for waypoint entry by using Range/Bearing from present position in the CLC Mode. The calculated position from the range and bearing you have entered are displayed in the upper two lines and stored into the "To" waypoint selected in the third line. You will see the N, S, E, W hemisphere indicators flashing in the CLC Mode to warn you that the L/L shown is not your present position.

You must be very careful that the waypoint into which you want to put the new information is empty before doing this operation. Otherwise a waypoint with desired position already entered into it will be overwritten instantly, and you will lose any information you may have wanted to keep. Before calling up the CLC Mode, look at the target waypoint to make sure that the L/L stored there is zero/zero by using the WPT Mode.

Assume for sake of illustration that your present position is 37 degrees 38.01 minutes North latitude, 122 degrees 24.01 minutes West longitude in San Francisco, and that you have found an interesting target on your radar with a range of 3.4 n.m. and a relative bearing of 135 degrees off your starboard bow. The magnetic compass reading at the time is 46 degrees.

The target of interest is thus at a bearing of 46 plus 135 degrees magnetic, or in other words, a magnetic bearing of 181 degrees. We assume now that your LC-90 is set up for automatic Magnetic Variation operation. Let's put the position of this target into waypoint 32. First, get into the CLC Mode.

1. Type the desired "To" waypoint on the third line, where at this time the cursor is blinking, waiting for data entry.

   [CLR] [3] [2] [ENT]

The cursor will automatically advance to the next line.

2. Type in the range of 3.4 n.m. and 181 degrees magnetic, using the following keystroke sequence:

   [CLR] [0] [3] [4] [ENT] [CLR] [1] [8] [1] [ENT] Range = 3.4 n.m.
   Bearing = 181 deg. mag.

The result will be displayed in the upper two lines. During the calculation, the degree indications will be flashing. Wait until the L/L readout and the flashing degree indications stabilize before proceeding to another Mode or Function.

SELECTING WAYPOINT(S) FOR USE WITH OTHER MODES AND FUNCTIONS (NAV Mode)

To prepare for making navigation calculations using waypoint(s) you must first select either the single waypoint towards which you want to proceed from your present position, or you must specify the two waypoints between which you want to travel. The NAV Mode is used to select waypoint(s) for later use in other Modes.

To specify the waypoint(s) of interest, call up the NAV mode by pressing ◀ or ▶ to line up the Mode indicator directly over the "NAV" label on the panel under the display. The display should now look similar to the figure below, where the cursor will be flashing on the third line.

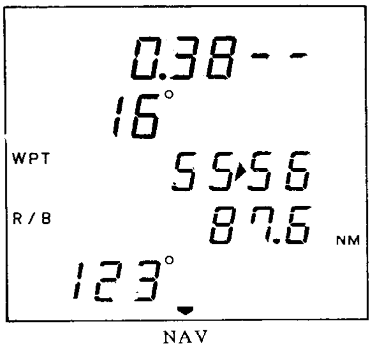


Fig. 20 NAV Mode Screen

There are three ways in which Waypoint information may be selected in the NAV mode:

a. As a destination waypoint from your present position (00).

b. As a pair of waypoints, the left-hand one being the "From" waypoint, and the right-hand one being the "To" waypoint.

c. As a pair of waypoints in a Route, which is a preplanned set of waypoints which you want to follow in sequence. This latter type of waypoint selection in the NAV Mode will be covered later on in this section when Route Planning is discussed.

Selection of a Destination Waypoint from Present Position (NAV Mode):

First, let us select a single waypoint towards which you want to navigate from the present position. This is normally used when you want to do a simple Range/Bearing computation from your present position to the desired waypoint location.

Waypoint zero zero ("00") has been described as a unique waypoint. "00" always refers to the present position of the LC-90. In fact, if you call up "00" in the WPT Mode, you will find that you cannot enter data into it. In order to specify a waypoint to navigate towards from your present position you need to specify the waypoint selection as "From 00" to the "To waypoint" of interest. As complicated as this is to explain in words, it is really a simple process. Let us say that you want to proceed to waypoint number "04" from your present location. Suppose further that waypoint number "04" has already had a position stored in it, let's say the position of a buoy outside the harbor. Make sure first that you are in the NAV Mode, and then key in the following:

[CLR] [0] [0] [0] [4] [ENT] From waypoint 00 To waypoint 04.

You should see an arrow in the third line separating the "From 00" and the "To 04" waypoints. In other words, the two digits on the left-hand side represent the starting waypoint and the right-hand digits represent the destination waypoint.

If you would like to confirm the coordinates of each waypoint, call up the WPT Mode and enter the waypoint number desired. If the waypoint has been specified by TD's you may hit the [TD ↔ L/L] key to see the TD's. Make sure that you hit the [TD ↔ L/L] key again to get back into the L/L format.

Specification of a Pair of Waypoints ("From"/"To" Waypoints) (NAV Mode):

Now let's try selecting a pair of waypoints. This is done whenever you want to use Cross-Track Error or go between two waypoints. This is also needed when you wish to specify a line defining the Border of a particular zone which you want to avoid. Both Cross-Track Error (XTE) and Border alarms will be described in detail later on in this section.

Let's say that you want to set up a voyage between waypoints 55 and 56. You would make sure that you are in the NAV mode by moving the left or right arrow keys to line up the Mode indicator directly over the "NAV" label on the front panel under the display. As usual, the cursor will have automatically placed itself at the first point at which data may be entered, on the third line. You would key in:

[CLR] [5] [5] [5] [6] [ENT] From waypoint 55 To waypoint 56.

The display will show the starting waypoint "55" on the left-hand side, with an arrow pointing to the right towards the destination waypoint "56."

You can now go to another function which uses waypoints, since you have specified the waypoints of interest.

RANGE AND BEARING CALCULATIONS (R/B and CLC Modes)

To steer to a waypoint, you would like to have two pieces of information: the direction in which to steer, and the distance to the waypoint. The LC-90 provides two forms of Range/Bearing calculations to aid you in navigating to a waypoint or in navigating from waypoint to waypoint:

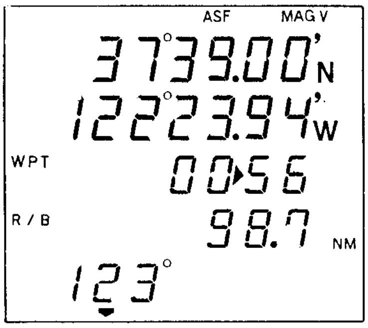
a. Simple Range/Bearing from Present Position to a waypoint (R/B Mode).

b. Range/Bearing from waypoint to waypoint (CLC Mode).

Simple Range and Bearing from Present Position to a Waypoint (R/B Mode):

The range and the bearing from present position is the most basic information you can use to navigate to a waypoint. You have learned how to select a destination waypoint in the NAV mode in the section above. Now, select the R/B Mode by moving the Mode indicator with the left or right arrow keys until is it lined up directly over the "R/B" Mode label. The range and bearing from your present position to the waypoint selected in the NAV Mode (calculated on the basis of a Great Circle course) will be displayed on the bottom two lines in the R/B display. The range is in nautical miles and the bearing is normally Magnetic. If the indication "MAGV" doesn't appear at the top right of the display, this indicates that you have manually set "00" as a variation, and that the bearing is thus relative to True North.

Fig. 21 shows a typical R/B display.



R/B

Fig. 21 R/B Mode Screen

Range and Bearing Between Two Waypoints (CLC Mode):

In the process of planning a voyage, a series of waypoints is usually selected in advance, and a Range/Bearing calculation is made to get the heading to use for the first leg of the voyage. As you approach the first waypoint, you then will want to calculate in advance the next heading to take in order to get to the second waypoint after you round the first one. To do this you will need to use the CLC Mode in the LC-90.

The procedure is straightforward. In this Mode you needn't respecify the waypoints presently being used by using the NAV Mode. Instead, you may make this calculation "offline" (to use some computer jargon) without affecting normal operations of the LC-90, which may have been navigating between two waypoints already previously selected in the NAV Mode. You wouldn't want to change the present voyage parameters in order to do a planning calculation. Let's say that you are presently traveling from waypoint 56 to 57 (selected in the NAV Mode), and that you want to determine in advance the heading to set into your autopilot after you round waypoint 57 on the way to the next waypoint 58.

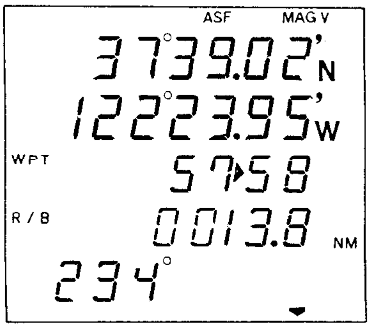
1. First, get into the CLC Mode, using as usual the left or right arrow keys to line up the Mode indicator arrow over the "CLC" label. The cursor will automatically place itself on the third line.

2. Now key in the following:

   [CLR] [5] [7] [5] [8] [ENT] From waypoint 57 to 58.

   You will now see the Range and Bearing for the voyage from waypoint 57 to waypoint 58 displayed on the fourth and fifth lines respectively.

   See the figure below for a typical display screen.



CLC

Fig. 22 CLC Mode Screen

CROSS-TRACK ERROR FUNCTIONS (XTE Mode)

On a voyage between a starting waypoint and a destination waypoint, the desired course between the two positions is known as a "track." It could just as well be termed the "intended track" because although it is the intention of the user to follow this course faithfully, in reality, he never can do so perfectly. The forces of wind, waves, current and even steering errors or boat loading imbalances and propeller speed mismatches on multi-screw boats can combine to throw the vessel off the desired track.

Of course a sailboat has an even tougher time sticking to an intended track, since it must constantly tack to move in spite of the wind direction. We'll describe another function (the VTD Mode) later which is designed to help the sailboater achieve maximum efficiency in spite of the vagaries of the wind.

The amount which the boat is thrown off the intended track is termed the "Cross-Track Error," often abbreviated "XTE." The angle of offset from the intended track due to current, wind and other factors is referred to as the "Course Offset." The LC-90 is capable of calculating the offset necessary to get back on course to your intended destination. Note: if whatever was causing you to be off-course in the first place remains in effect, there will be a continuous series of commands to change heading to get back on course, unless you use an autopilot, where you can add the course offset angle, and in effect "crab" your way to the destination.

Look at the drawing in Fig. 23. The perpendicular line from the intended track to the actual position of the boat (at some time after the voyage has begun) is the Cross-Track Error. The angle made by the actual track (if it were continued on without any compensation) to the destination is the Course Offset. In the example, it is necessary to steer to the left, with a new heading equal to the original heading minus 30 degrees, to compensate for the effect of wind and current.

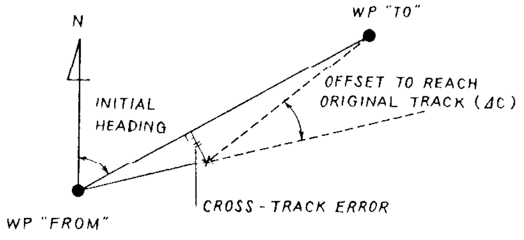


Fig. 23

In order to use the Cross-Track Error function you must first select a starting waypoint ("Waypoint From") and a destination waypoint ("Waypoint To"), using the NAV mode. Note: if you want to use your present position as the starting point from which you define a new track towards a destination waypoint this may be done easily also.

Get into the NAV Mode and enter your starting waypoint and destination waypoint. If you want to define your present position as the starting waypoint, simply specify "00" as the "From" starting waypoint. For example, if you are in the process of making a voyage From waypoint 55 to waypoint 56, and you are thrown so far off course by wind or current that it is inefficient merely to return back to the original track to continue on to waypoint 56, then you may use the NAV Mode to specify a new track by keying in "0056," which translates to: "From present position To waypoint 56." You will now see the Cross-Track Error and Course Offset (ΔC)

displayed on the upper two lines of the NAV Mode. You would however be better off going back to the XTE Mode rather than staying in the NAV Mode, since your present position isn't shown in the NAV Mode. Get back in the XTE mode by pressing ◀ or ▶ .

Fig. 24 shows a typical XTE display. Your present position is displayed on the upper two lines. The waypoint numbers selected are displayed next to the label "WPT" on the third line. The XTE on the fourth line varies from 0.01 to 9.99 nautical miles. The bar indicates to which side of the desired track the vessel is off track, and the arrow points in the direction in which you must steer to get back on course. If the XTE is within the preset alarm zone, a single arrow and bar will appear. If the XTE exceeds the preset value, two arrows and bars will be displayed. (We will get into the setting of the various alarm zones later on in this section.)

The numbers on the bottom line describe the Course Offset (ΔC) and the Distance to the waypoint. The minus sign in front of the offset indicates that it is necessary to steer to the left. The offset angle is indicated up a maximum of 99 degrees. When you have passed the "To" waypoint, a minus sign will appear to the left of the distance display.

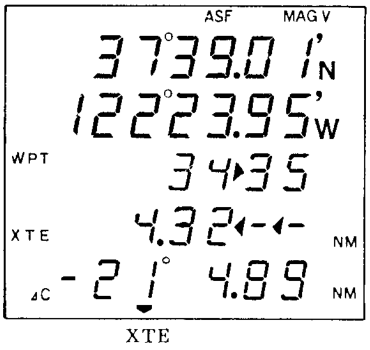


Fig. 24 XTE Mode Screen

VELOCITY TO DESTINATION AND TIME TO GO (VTD Mode)

Velocity To Destination (VTD) is differentiated from Speed Made Good in that VTD is a "vector" quantity while speed is a "scalar" quantity. A vector quantity denotes not only the magnitude of speed movement, but also the direction, whereas a scalar quantity denotes magnitude only. In this particular case then VTD defines the amount of speed in the direction of the desired destination.

The reason for all this seeming complication is that not only can wind and current move a vessel off its intended track, but so can intentional movements, such as when a sailboat tacks into the wind.

In the case of a sailboat it is very beneficial for the skipper to know how much headway he is making toward the desired destination as he tries various tacking angles to optimize his progress towards a mark.

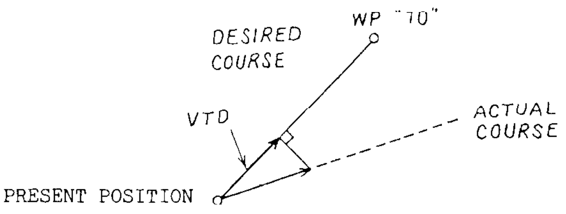


Fig. 25

The Time To Go (TTG) is the amount of time necessary to get to the desired destination if the present VTD is maintained. TTG is obviously an estimate, since in the case of a sailboat a series of tacking maneuvers is usually necessary in order to get to a location, and in the case of a powerboat the effects of wind and current are usually not constant over a voyage.

Unlike the Cross-Track-Error function, the VTD/TTG functions don't require both a starting and destination waypoint location; only a destination (Waypoint To) waypoint is needed. However, in the case of a powerboat especially, the XTE/ΔC and the VTD/TTG functions are usually used together. The operator uses the XTE function for instantaneous information to monitor the short-term deviation from his intended track, and the VTD and TTG for a long-term evaluation of the progress towards his destination. Thus it is a good idea to define both a "Waypoint From" and a "Waypoint To" for VTD/TTG functions as well as for the XTE/ΔC functions, using the NAV Mode.

The VTD is displayed in units of nautical miles per hour (knots), and the TTG is displayed in hours and minutes, up to a maximum of 99 hours, 59 minutes. Presuming that you have set up a "From" waypoint of 55 and a "To" waypoint of 56, the display screen below might be typical of what you would see when you call up the VTD Mode.

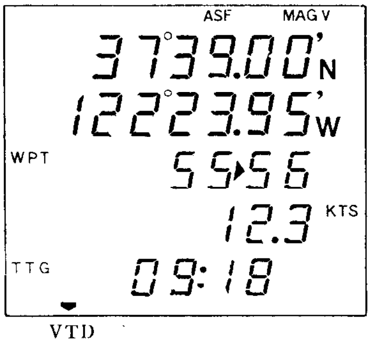


Fig. 26 VTD Mode Screen

ALARM FUNCTIONS (ALM Mode)

There are four conditions that can trigger the audible and visual alarms in the LC-90: an Off-course alarm which warns you that the Cross-Track Error has exceeded a preset value; a Border Alarm which warns that you are approaching too close to the border of an unauthorized zone (such as the border of another country); an Arrival alarm to signal that you have arrived near a destination waypoint; and an Anchor-Watch alarm which warns that the boat may be dragging its anchor. For each of these functions the operator may preset the limits he wants to work with.

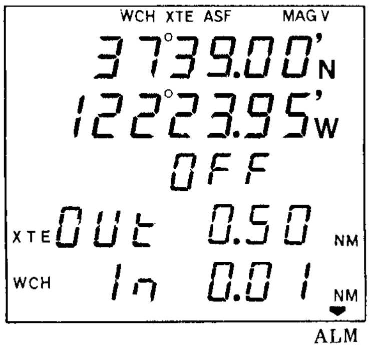


Fig. 27 ALM Mode Screen

Fig. 27 shows a typical ALM display. The present position is displayed on the upper two lines. The "ON" or "OFF" on the third line indicates whether the unit is preset to sound an audible alarm or not. This status can be changed by using the key sequence of [CLR] [+/-] [ENT]. The value for the "Off-Course" or "Border" alarm is entered on the fourth line, and that for the "Anchor Watch" or "Arrival" alarm is entered on the fifth line. (A limit of 0.00 means the alarm is off.)

The alarm will sound when the boat crosses the preset alarm zone from inside or outside. The "In" and "Out" on the bottom two lines indicate which direction is preset for the alarm function. "In" indicates that the alarm will sound if the vessel ventures into the area, and "Out" indicates that the alarm will sound if the vessel ventures outside the desired area.

If an alarm is activated, a visual alarm indication ("WCH" and/or "XTE") will also appear at the top of the display.

Off-Course Alarm (ALM Mode):

The Off-Course alarm is used when the Cross-Track Error function is being used. You may preset the alarm limit from 0.00 n.m. (i.e., the alarm is disabled) to a maximum lane width of 20 n.m. (that is, 9.99 n.m. each side of lane center). The Off-Course alarm will sound if you go out of the lane limits.

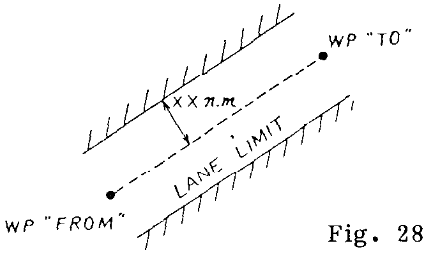


Fig. 28 Off-Course Alarm

For example, the touchpad sequence to use to enter a lane limit of one-half nautical mile is:

1. Select the fourth line by pressing ▼ .
2. Press [CLR].
3. Confirm that "OUT" is displayed next to the message "XTE". If not, press [+/-] to change the display to "Out."
4. Type [0] [5] [0] [ENT].

Border Alarm (ALM Mode):

The Border Alarm is used when you wish to define, between two waypoints, a line that you don't wish to cross. The alarm will sound when the boat comes into the hatched area as shown in the figure below.

For example, assume that you want to draw a line between Waypoints 7 and 8 and that we want to be sure you don't come closer than 1.5 n.m. to that border. Once you are in the ALM Mode, the touchpad sequence would be:

1. Select the fourth line by pressing ▼ .

2. Press [CLR] .

3. Press [+/-] if "OUT" is displayed on the fourth line to change it to "In."

4. Press [0] [1] [5] [ENT] .

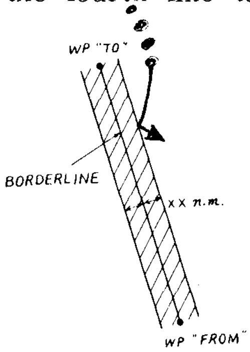


Fig. 29 Border Line Alarm

Arrival Alarm (ALM Mode):

The Arrival Alarm is used to warn that the boat is approaching a destination waypoint. The area that defines an Arrival zone is that of a circle, which you approach from outside the circle. The alarm will sound if the boat enters into the circle.

Note carefully that how "tight" the Arrival Alarm is set defines how close the boat must come to a desired destination waypoint before the alarm sounds. It also determines when the LC-90 will automatically switch to the next waypoint in a planned Route mode. Setting the Arrival alarm too loosely (i.e., with a large radius) will cause the waypoint to be switched automatically too far away from the desired point, possibly causing a dangerous situation. You must be very careful thus when setting the Arrival alarm limit if automatic waypoint sequencing is in use. A setting of about 0.1 to 0.2 n.m. should be reasonable for most situations.

For example, to set an Arrival Alarm limit of 0.1 n.m., you would use the following touchpad sequence, once you are in the ALM Mode.

1. Select the bottom line by pressing ▼ .

2. Press [CLR] .

3. Press [+/-] if "OUT" is showing already, to change it to "In."

4. Type [0] [0] [1] [ENT] .

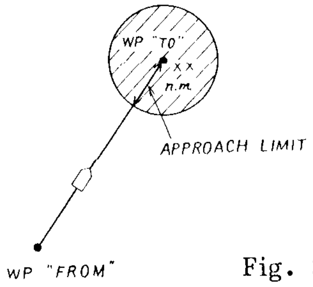


Fig. 30 Arrival Alarm

Anchor Watch (ALM Mode):

The Anchor Watch alarm function is used to ensure that you are notified should the boat drift outside a predetermined area while it is supposed to be at rest. The area that defines the Anchor Watch zone is a circle within which you want to stay, and the alarm will sound if the vessel goes out of the desired circle.

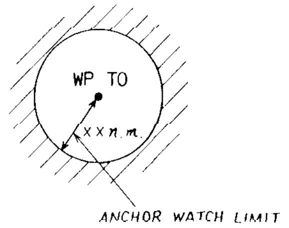


Fig. 31 Anchor Watch

For example, to set an Anchor Watch alarm limit of 0.03 n.m., you would use the following touchpad sequence, once you are in the ALM Mode:

1. Make sure the audible alarm is set. The third line should say "On".
2. Select the bottom line by pressing ▼.
3. Press [CLR] .
4. Confirm that "Out" is displayed next to the "WCH" indication. If not, press [+/-] to change the indication to "Out."
5. Press [0] [0] [3] [ENT] .

Note that if you set the Anchor Watch alarm zone too "tight," that you may have to get up in the middle of the night to reset it due to minor fluctuations in the Loran signals. You may need to do some experimentation to determine just how closely you want to set the alarm limit depending on your particular geographical area. Now select an open waypoint (perhaps, 99) in WPT Mode and store your present position there by hitting the [EVT] key. Go to the NAV Mode and key in: [0] [0] [9] [9] [ENT] . Now if you drift out of the Anchor Watch zone the alarm will sound.

ROUTE FUNCTIONS (PLN Mode)

In many cases a trip from one place to another involves several course changes, requiring a series of waypoints which you navigate to, one after another. The sequence of waypoints leading to the ultimate destination is called a "Route." The PLN Mode is used to create a Route Plan.

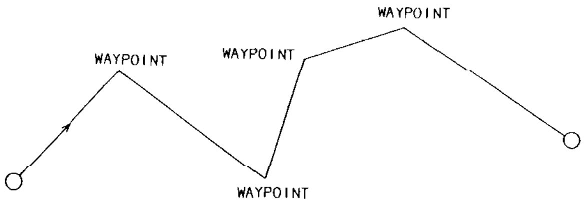


Fig. 32

You may store a maximum of 10 routes in the LC-90, and the unit will tell you how to steer along each of these routes when you call them up. Routes are stored permanently in the unit's memory even when the unit is turned off. Each route consists of a maximum of 10 waypoints and is given an identification number so that you may call up any route and use it. The LC-90 can automatically advance to the next waypoint on a route, so you don't have to change the destination waypoint repeatedly on a voyage, provided that you have activated the Arrival alarm in the ALM Mode.

Note very well and very carefully: although the Route Planning Mode is a very useful and beneficial one to have available, the ability to switch waypoints automatically during a voyage can potentially lead to some very dangerous situations. If when using the automatic waypoint switching facility you set the Arrival alarm too loosely, you can "cut a corner" around a waypoint, leading to possible collision with other vessels or leading to a possible grounding if you come too close to land. Use of any navigational aid requires constant exercise of common sense and caution!

Routes can be used for:

1. Point to point navigation (steering a precise, straight line between two points over which you often travel.)

2. Repetitive running of a complex route, such as a harbor entrance channel.

3. Returning to particular areas, such as locations of lobster traps, or prime fishing spots.

Storing a Route (PLN Mode):

Before entering waypoints, the coordinates for each waypoint should be determined and entered in the WPT Mode. See the section on using the WPT Mode. In addition, you should set the Arrival Alarm limit, as described in the section on Alarms.

CAUTION

Be sure to record all important routes in a separate log. The LC-90 is intended for use as a navigational aid; not a fail-safe record keeping device. Neither is it intended to be used without caution regarding possible dangerous navigational situations. A sequence of waypoints leading out of harbor does not take into account any vessels recently anchored nearby, nor does it take into account buoys or navigation markers which may have drifted.

Press ◀ or ▶ to get into the PLN Mode. The display will look similar to the one below.

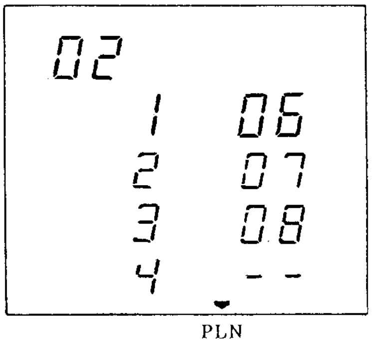


Fig. 33 PLN Mode Screen

The number on the top line is the route number. The LC-90 is capable of storing a maximum of 10 routes, numbered 01 to 10. Each waypoint in the route is shown in numerical sequence, starting at 01 and continuing to 10.

A maximum of ten waypoints can be stored and then observed later by scrolling the display upward by one line with the ▼ key. A "--" in the display shows that no waypoint has been previously stored there.

Now as an example, let's enter waypoint 06 as the first waypoint in a Route we shall create, called Route 02. First, enter the PLN Mode. The touchpad sequence would be:

1. Press [CLR] and the top line will show "--".

2. Press [0] [2] [ENT]. After [ENT] is pressed, the left bar on the second line will blink, indicating that the cursor has automatically advanced to this position.

3. Press [CLR] followed by the waypoint number [0] [6] [ENT].

4. Repeat step 3. for succeeding waypoints of your choice.

Following a Route (NAV Mode):

Following a route in the forward or the reverse direction is the process by which a stored route is used for navigation. The LC-90 displays navigation information to guide you from one waypoint to the next, as it automatically switches from waypoint to another in sequence (if the Arrival alarm has been activated) and if you do actually arrive at a particular waypoint. More on this point later.

To follow a route which you have previously programmed into the unit:

Get into the NAV Mode and specify the two digits designating the desired route on the third line of the display. If you would like to traverse the route in the reverse order, for example to return back to port, press the [+/-] key before typing the route number. For example, to follow route 02 in the reverse order, type [CLR] [+/-] [0] [2] [ENT]. The third line of the NAV display should now appear as below, showing Route 02, where you are now travelling between waypoints 34 and 56.

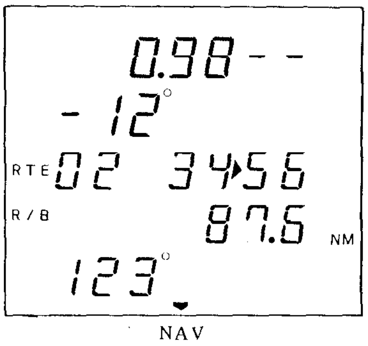


Fig. 34 NAV Mode Screen

The selected route number is displayed on the third line followed by the waypoint numbers in the route. The next waypoint is shown as the two digits on at the right hand side of the arrow. Note that the LC-90 will automatically select the first waypoint in the Route plan for you to go towards from your present position. Thus if the first waypoint in a Route is for example waypoint 34, then the display would show "00 - 34." Once you arrive within the radius of the Arrival Alarm limit, the LC-90 will signal your arrival by sounding the "WCH" buzzer for ten seconds. Then it will automatically switch to the next waypoint in sequence. For example if the next destination waypoint is 35, then the display would show "34 - 35."

As described before, the LC-90 will automatically display the next waypoint after passing the waypoint in use. Get into the VTD, R/B or XTE Modes so that you can see your navigation information to the destination waypoint.

In many common situations you may never actually "arrive" at a destination waypoint, and thus you may not see the unit automatically switch to the next destination waypoint. For instance, if you have specified an Arrival Alarm radius of 0.10 n.m., and your destination waypoint 35 is a buoy in a busy harbor, you may find when you get close to that buoy that a tanker has anchored nearby, blocking you from ever reaching your destination.

Obviously you are going to have to dodge the obstacle, and in so doing you would find that your Range to the desired waypoint would be increasing rather than decreasing as you swerve around the tanker. In this case you will manually have to override the automatic waypoint sequencing.

You might also try another way to "arrive" at your destination waypoint. This involves changing the Arrival Alarm limit to a larger number. This way too is fraught with danger, for if you specify the Arrival limit too loosely, let's say 0.50 n.m., you will indeed allow the automatic switching to the next destination waypoint to occur, but you may then define a new course to the next waypoint that takes you through a seawall or over land!

If is far better to leave a reasonable Arrival Alarm limit of, say 0.10 n.m., and when you get as close as safely possible to the desired waypoint which is now blocked then manually override the Route planning Mode and go to manual waypoint sequencing. If you are adamant about staying in the automatic waypoint sequencing Mode, then you may take another tack: you may temporarily deselect waypoints that you have already passed, and then proceed automatically again.

<u>Temporarily Deselecting a Waypoint in a Route (PLN Mode)</u>:

A waypoint in a route may be deselected temporarily by entering a "-" (minus) to the left of the waypoint number selected in the PLN mode. The temporarily neglected waypoint may be used again at any time by changing the "-" with the [+/-] key. For example, let's use our tanker problem situation, where the original Route Plan was:

Route 02

1	01
2	02
3	05
4	06
5	07
6	08

Let's assume that you have successfully negotiated waypoints 01 and 02, and that you are presently going from waypoint 02 to waypoint 05. You find that you are blocked from arriving at waypoint 05 by the tanker. After you dodge the obstacle, you now want the LC-90 to get you from your present position to waypoint 06, and then from waypoint 06 to 07, etc. afterwards. You must temporarily delete route waypoints 01, 02, and 05 before calling up your desired Route plan 02 again in the NAV Mode. You would use the following key sequence to temporarily delete these waypoints.

1. Put the unit in the PLN mode.

2. Select waypoint 1 by pressing the down arrow cursor.

3. Press [CLR] [+/-] [ENT] . (Typing waypoint 01 is not necessary.)

4. Do the same for the next two waypoints.

Now, when you respecify Route Plan 02 in the NAV Mode, you will find that the LC-90 tells you that your waypoints are from "00 - 06." When you do pass waypoint 06 successfully, the unit will sound the ten second long Arrival Alarm, and will then switch to the "06 - 07" waypoint sequence.

EVENT ([EVT] Key)

Storing Present Position into an Event Memory (Mode: any, except for WPT):

When you press [EVT] in any Mode, except for the WPT mode, the position of the vessel at the exact moment the key is pressed will be stored in the Event memory for future reference. (It isn't possible to access the Event memory when you are in the WPT Mode, since by definition you are concerned in that Mode strictly with Waypoint memory.) Up to 10 such Event locations may be saved. If you try to save more than 10 locations, the earliest locations will be overwritten, one at a time, to make room for the latest positions.

CAUTION

Be sure to keep a separate copy of important positions. The LC-90 is a navigation aid; it is not intended to be a secure record-keeping device.

Press [EVT] in any mode except for the WPT Mode. The stored position is automatically put into Event Memoey number 01, and any earlier EVT positions are shifted upwards by one number. What was earlier in number 01 will thus shift up to number 02. When there are 10 Event numbers already stored in memory, putting in another one will cause Event number 10 to be overwritten by what was previously number 09. You may call up the stored position by using the secondary Function #0. Press [#] followed by [0] and the Event display will appear as shown in Fig. 35.

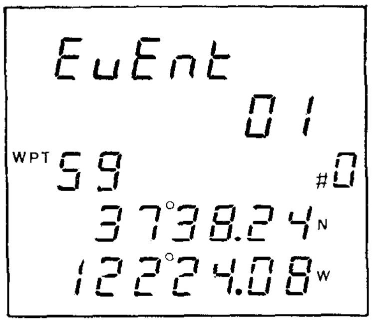


Fig. 35 EVT Mode Screen

Select the event number you wish to display and the position data for that Event number will appear on the bottom two lines.

The LC-90 allows you to transfer the data from an event memory number to the waypoint memory if you want to. You need only specify the waypoint number where you want to data from the Event memory transferred. Be careful here. Any data that is already stored in the targeted waypoint will be automatically overwritten when you do the transfer. It is advisable to

check the target waypoint before you attempt to transfer position data from an Event Memory to make sure it is unused.

Select the desired event number on the second line by first pressing [CLR], and then typing the desired Event number (two digits long), followed by [ENT]. Then select the Waypoint number into which you wish to transfer the data from the Event number. The cursor will automatically have moved down to the third line after you pressed the [ENT] key. You would now press the [CLR] key, and then type in the desired Waypoint number, followed by [ENT].

For example, let's say that you want to observe the position stored in Event memory number 05, and that you then want to transfer that data into Waypoint number 59. The touchpad sequence would be as follows:

1. Get into the Event Function #0 by hitting the [#] key, followed by [0].

2. Hit [CLR] [0] [5] [ENT]

3. Hit [CLR] [5] [9] [ENT]

4. Now verify that Waypoint 59 actually contains the Event data by accessing the WPT Mode and calling up Waypoint 59.

Storing Present Position into a Waypoint Memory (EVT in WPT Mode):

When you press [EVT] in the WPT mode, the present position will be recorded into the waypoint memory number you have specified, as has been already described. Put the LC-90 into the WPT Mode by using the left or right arrow keys to move the Mode indicator arrow to line up directly over the "WPT" label. The cursor will be flashing on the third line. Hit the [CLR] key, specify the waypoint number into which you want to store present position, and then hit the [ENT] key. Make sure that you are in the Latitude/Longitude format in order for this function to work properly. Now you can press the [EVT] key. Note that your present position has now appeared on the bottom two lines of the display.

CONVERTING COORDINATES (WPT Mode)

The LC-90 enables you to convert position coordinates from TD format to Latitude/Longitude format and vice-versa in the WPT Mode. First, get into the WPT Mode using the left or right arrow cursor keys. Select an empty waypoint memory number; i.e., one where the L/L is all zeroes. If you try to make a conversion using a waypoint that already has data stored into it you will lose the earlier information completely.

Note also that the TD's you enter must be the same as the slave TD's actually in use by the LC-90 and that the GRI must be the same as the one presently in use. For example, assume the GRI is 9940, and the two slaves in use are the 27 and 43 lines. We want to convert the following TD's to L/L: 43156.7, and 27245.9 microseconds.

1. Call up the WPT mode.

2. Select an empty waypoint number (a waypoint where the L/L is all zeroes) on the third line.

3. Press [TD ↔ L/L] to change the position display to the TD format, if necessary.

4. Type TD1 on the fourth line: [CLR] [4] [3] [1] [5] [6] [7] [ENT] .

5. Type TD2 on the bottom line: [CLR] [2] [7] [2] [4] [5] [9] [ENT] .

6. Press [TD↔L/L] to perform the conversion.

To convert L/L to TD's, specify the desired (empty) waypoint number, type in the desired Latitude and Longitude while in the L/L format, and then press the [TD↔L/L] conversion key.

Note that the LC-90 stores all waypoints as L/L positions rather than as TD positions. The conversion between L/L and the corresponding TD's thus may be a little bit different from measured TD's, perhaps as much as 0.1 microsecond. This is the result of normal computational accuracy due to rounding-off of numbers in the internal calculations.

ADVANCED LEVEL OPERATIONS

WARNING INDICATORS

The warning indications on the LC-90 serve important functions, advising you when extra caution should be exercised because of a possible problem with the Loran signals.

Don't use position data from the display until all signal warning indicators have been extinguished. These include "MCYC"/"MSNR" for Master, "CYC"/"SNR"/"BLK" for both slaves and "PF."

The figure below shows secondary Function #6, displaying various receiving status indications.

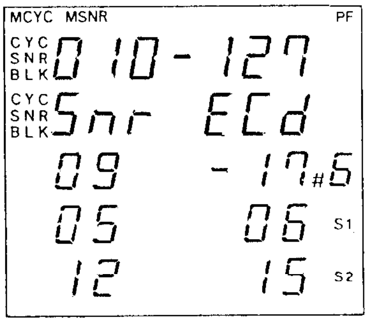


Fig. 36 Function #6 Screen

SNR Indicator (Function #6):

If the SNR warning indicator for any of the stations appears, the signal may have become too weak to use. In fact, the receiver may have lost track completely or the station may have gone off the air.

SNR means "Signal to Noise Ratio" and is a relative measure of the quality of the signal in the presence of noise, either generated locally on the boat or generated in the ionosphere.

The SNR function is also used by a servicing technician to evaluate problems either in the set itself or problems with noise generated on the boat. To call up the SNR function, type [#] [6]. The SNR for each station will be displayed on the lower three lines as shown in Fig.36.

The table below lists the numerical values for SNR, and shows what the various values mean.

SNR Value Table

SNR READING	DESCRIPTION	SNR INDICATOR
00 to 14	Too weak to track (signal lost)	ON
15 to 99	Auto-aquisition/ tracking OK	OFF

CYC Indicator (Function #6):

If the "MCYC" ("Master Cycle") indicator for the master or "CYC" ("Cycle") indicator for either of the two slaves is on, the LC-90 is trying to warn the operator that it may well have locked onto the wrong cycle of the Loran-C signal.

All modern receivers track on the third cycle of the pulse. The signal amplitude at this point is not terribly high, so in weak areas, the receiver might become confused and lock onto the fourth rather than the third cycle, since the fourth cycle is stronger. If this occurs on the Master signal alone, the slave signals will be 10 microseconds lower, and the position data (TD's) obtained will be in error; by as much as 3 n.m.

The LC-90 employs sophisticated mathematic algorithms to reduce the possibility of a 10 microsecond error caused by weak signals, but if the shape of the Loran-C pulse is distorted by passage over land, or by reflection from other vessels, or even from masts or conductors on your own vessel, cycle locking problems could occur.

In the top line of the secondary Function #6, the LC-90 displays which cycle is tracked by the receiver.

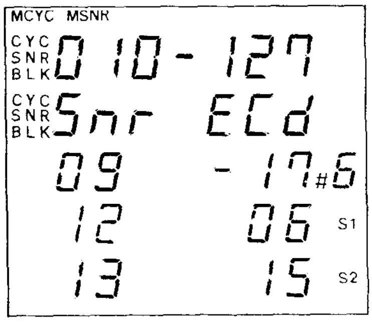


Fig. 37 Function #6 Screen

See Fig.37. "010" is displayed at the left-hand side of the top line. The figures from left to right indicate the tracking points for the Master, Slave 1 and Slave 2 signals, respectively; "0" indicates that the receiver thinks it is tracking on the correct cycle and "1" indicates that the receiver suspects that it is tracking on the wrong cycle. For example, in Fig.37, the slave 1 signal is shown as tracking on the wrong cycle.

ECD (Function #6):

The definition of "ECD" is "Envelope to Cycle Difference." This refers to the distortion of an actual pulse received off the air as compared to the theoretical shape. The LC-90 can display a relative indication of the magnitude of the problem by using Secondary Function #6.

Deviation (Function #6):

The amount that the internal reference oscillator in the LC-90 has drifted from its preset value is called the Deviation. The LC-90 compares the frequency of its own internal oscillator with that transmitted by the Loran-C stations, all of which have extremely precise master oscillators.

The nominal value for DEV is 000, set at the factory. If the oscillator drifts too far, signal acquisition time may increase and tracking accuracy may be affected. If this should occur the unit must be serviced.

The first table below lists the numerical values for ECD, and the second table lists the numerical values for "DEV."

ECD and DEV Table

ECD READING	DESCRIPTION	CYC INDICATOR
-17	Tracking on earlier cycle	ON
-16 to -11	Signal distorted, might be tracking on earlier cycle.	
-10 to 10	Tracking on correct cycle	OFF
11 to 16	Signal distorted, might be tracking on later cycle.	
17	Tracking on later cycle	ON

DEV READING	DESCRIPTION
-99 to 99	Normal aquisition/ tracking attainable
Less than -99 or more than +99	It may not acquire signals, or even it once acquired, might lose tracking easily.

Fig. 38

Audible SNR (Function #7):

In Function #7, if you override the SOUND.OF function on line 1 to show Sound On (use the [CLR] key followed by [+/-] [ENT]) you can use the audible SNR function. In addition to the visual SNR readings shown on the display, the duration of the beeps emanating from the buzzer indicates SNR quality. The shorter the duration and the longer the time between beeps, the poorer the indicated SNR is. You might use this function while remotely trying various antenna positions.

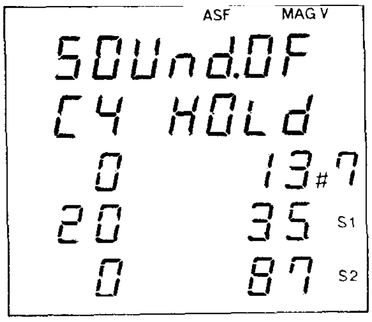


Fig. 39 Function #7

Audible SNR Table

SNR VALUE	AUDIO TONE INTERVAL
0 to 20	- - -
20 to 30	- - - -
30 to 40	- - - - - - - - -
40 to 50	- - - - - - - - - - - -
50 to 60	- - - - - - - - - - - - - - -
60 to 70	- -
70 to 99	———————————

BLINK Indicator:

If there is a problem at one of the transmitting stations, it will begin to transmit a warning indication called "Blink." The LC-90 responds by producing a blink indication that tells the operator which station is having problems. If slave 1 is faulty, the blink indicator (BLK) will come on at the far left-hand side of the top line; if slave 2 is faulty, the blink indicator (BLK) will come on at the far left-hand side of the second line and both blink indicators will come on if the master station is faulty.

In some areas of Loran-C coverage it may be possible to switch to a different slave station if the one in use begins to blink, but if the master station is faulty all you can do is wait for the problem to be fixed at the station.

Power Failure Indicator:

If the main power for the LC-90 has gone off sometime during operation, and if the operator hasn't noticed this, the LC-90 will automatically reacquire the Loran-C signals after power is restored. However, there is a possibility that a tracking or acquisition error may have occurred. To warn the operator to check the position for accuracy the LC-90 turns on the "PF"("Power Failure") indicator to tell the operator that power was lost sometime in the past. To extinguish this indicator, press any key.

MANUAL CONTROL OF LORAN RECEPTION

Though fully automatic, the LC-90 has several manually activated signal reception controls, which may need to be employed on rare occasions.

The experienced operator should become familiar with these controls and their use, as navigation under extraordinary conditions may demand some degree of manual Loran signal control.

NOTE

It is strongly suggested that these manual controls not be used unless they are required due to especially poor signal conditions, and unless they are fully understood by the user.

Manual Cycle Selection (Function #5):

When navigating at long distances from the Loran transmitters, it may become necessary to step the cycle track points forward to a stronger part of the pulse. Also, under conditions of extremely severe signal distortion, it might be necessary to aid the LC-90 in selecting the correct 10 microseconds tracking point. Manual cycle stepping may expose you to skywave contamination, with consequent navigational inaccuracy. However, you would only use this function in extreme fringe areas anyway, where some Loran coverage is better than none at all.

When employing the manual cycle selection, remember these points:

- Increasing a secondary transmitter by 10 microseconds will cause that TD to read 10 microseconds higher.

- Increasing the master by 10 microseconds will cause both of the slave TD's to read 10 microseconds lower.
- Increasing all transmitters by 10 microseconds will leave the TD's unchanged.

The tracking point is stepped manually by the following procedure:

1. Enter Function #5 by pressing [#] and [5]. Do not press [ENT] at this time. The display will look like Fig. 40. The TD's being received are displayed in the upper two lines.

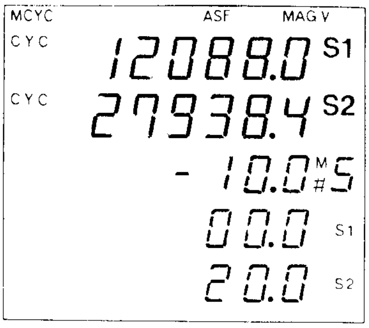


Fig. 40 Function #5 Screen

2. Enter a 10 microsecond value (or multiples of 10 microseconds) for the correction on the lower three lines: the third line is used for the master, the fourth line is for S1 and the bottom line is for S2. After pressing the [CLR] key, each line will show "_ 0.0." Then, type the correction value, followed by [ENT]. For example, if you want to shift the tracking point of the S2 secondary 20 microseconds higher, you would enter "20.0" on the bottom line after CLR'ing that line.

Manual Notch Filter Setting (Function #9):

Loran-C receivers are vulnerable to interference in the region of 60 KHz to 140 KHz coming from sources such as Decca chain transmitters or military low frequency communication transmitters. The LC-90 contains six notch filters to notch out and eliminate such interfering local signals.

Normally, these filters are used automatically, since they will seek out and notch offending signals very accurately all by themselves. There may be very rare occasions when you may wish to notch out an interfering signal manually. To do this, you must know the frequency of the interference. For example, there is a very strong military transmitter operating on the frequency of 88 KHz in the mid-Atlantic region of the U.S. This transmitter can cause problems when a vessel comes close to its location near Annapolis, Maryland. In this case it may be necessary to put two notch filters on the same frequency of 88 KHz in order to knock down the level of this transmitter sufficiently for the receiver to operate properly.

To tune or disable a notch filter manually, use the following procedure:

1. Press [#] and [9]. Filter numbers are displayed on the top line in the secondary function #9. See Fig.41. When the unit is first turned on after

installation, six A's are displayed on the second line, indicating that the receiver is using Automatic notch filter operation.

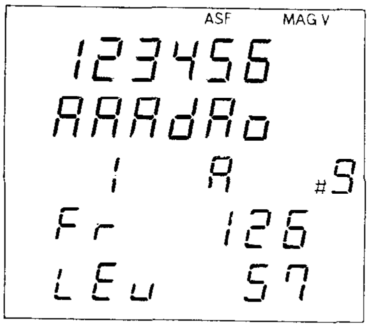


Fig. 41 Function #9 Screen

2. On the third line, type a filter number after pressing [CLR]. (Do not press [ENT] at this moment.) Let's assume that you want to use notch filter 4. Hit the [4] touchpad.

3. Press [+/-] until the indication "d" (referring to Disabling the Automatic notch filter operation) is displayed next to the filter number for manual tuning. (To disable the filter completely, press [+/-] until an "o" (referring to Off) is displayed.)

4. Now press [ENT].

5. Type the frequency of the interfering signal on the fourth line. For example, press [CLR] [0] [8] [8] [ENT] for an interfering signal of 88 KHz. The signal strength of the selected frequency can be read on the bottom line.

6. You would do the same procedure from 2. through 4 above. if you also wanted notch filter number 5 for example to be assigned manually to 88 KHz duty.

7. To return to automatic tuning, you would need to hit the [+/-] key until an "A" (Automatic) is displayed on the third line instead of "d" or "o".

8. The frequency and level of the interference signal eliminated by each notch filter can be read on the lower two lines while the filter number is specified on the third line.

MANUAL POSITION OFFSET CORRECTIONS

The LC-90 is capable of storing L/L correction and/or TD corrections internally for compensation of the L/L readout so that it more closely matches the actual position of the vessel as shown on a navigation chart. This manual compensation facility is in addition to the automatic ASF compensation function. You must thus be careful that you don't inadvertently call up both functions simultaneously, because then you will be in effect making a double compensation you probably didn't intend to invoke.

The LC-90 has ten "pages" into which correction information either by L/L and/or by TD may be entered. These pages are identified by the exact GRI and slave TD's that are entered into each page, and will be automatically

invoked by the computer whenever the vessel enters an area bounded by these numbers. For example, if you specify a set of correction values in page 01 using a GRI of 9940 (U.S. West Coast chain), with slaves of 42 and 26, then this page will be invoked only when the first two digits of the boat's slave TD's are equal to 42 and 26, when the GRI of 9940 is in effect.

This manual position offset correction facility should be specified only for areas where automatic ASF corrections are not available. At present the LC-90 has correction values built-in for the entire U.S. and Canadian coasts, but since correction values are presently not available anywhere else in the world, the ASF corrections outside these areas are absent.

L/L Correction (Function #2):

Variations in signal propagation velocity can cause constant errors in the computed Lat/Long position. In geographic areas where automatic ASF corrections aren't available you may want to enter manual L/L corrections.

In other cases, you may want to further refine the absolute accuracy of L/L coordinates to match a particular chart, where the chart has been drawn using a different datum reference than the WGS-72 datum used by the LC-90.

In either of these cases, you must first determine the amount by which you need to shift the L/L readings. This is done by comparing the displayed L/L with the actual L/L that you want the unit to read, or by using the correction data printed on the chart itself.

In the first case where you you are presently located at a position whose L/L coordinates are accurately known, you may compute the difference in L/L between what the LC-90 is showing and what you know to be the actual coordinates. Then you would enter the differential values as manual L/L corrections.

The second case is where you want to match up your L/L coordinates with that of a chart printed using a different datum reference. The LC-80 calculates Latitude/Longitude coordinates according to the "WGS-72" (World Geodetic System 1972) datum model. Many older charts are drawn using other datum models, for example, "Clarke 1866/1880" or "Bessel 1841." The position calculated by the LC-90 may not be the same as the expected position on these older types of charts.

For example, reprinted below is a comment found on an older U.S. DMA chart. On this chart it is necessary to add corrections of 11.49 seconds South (11.49/60 = 0.19 minutes South) and 10.33 seconds East (10.33/60 = 0.17 minutes East remember, the LC-90 uses tenths minutes rather than seconds.)

WORLD GEODETIC SYSTEM DATUM ADJUSTMENT
To place this chart on WGS-72 Datum, shift all parallels 11.49 seconds South and all meridians 10.33 seconds East.

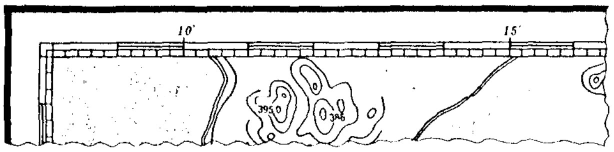


Fig. 42

1. Get into Function #2 by pressing [#] followed by [2]. You should see a display similar to the one below. The previously used offset values are displayed on the readout (the offsets will be zero is they haven't been specified previously.)

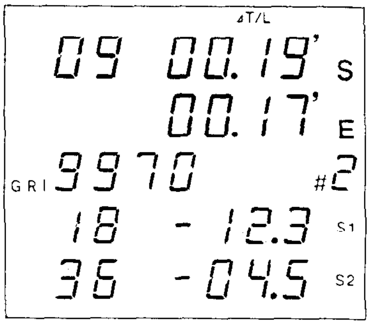


Fig. 43 Function #2 Screen

2. The page identification number is displayed on the left-hand side and the offset value for Latitude is on the right-hand side on the top line. The offset value for Longitude is displayed on the second line.

   The GRI and slaves where the corrections will automatically be used appear at the left-hand side of the lower three lines as shown in Fig.43. As explained previously, these values for GRI, S1, and S2 are important, for only when the boat enters the exact area bounded by these values will this page of corrections come into effect automatically.

3. Specify a page identification number and enter the offset value for Latitude on the top line. (If you want to enter TD corrections instead of L/L corrections, you would skip this step, and go on to the section for entering TD corrections.) For example, an identification page No.09 (two digits) and a correction of 00.19 minutes South may be entered by using the following keystroke sequence:

   [CLR] [0] [9] [0] [0] [1] [9] [+/-] [ENT]   00.19'S Latitude Correction

4. The cursor will automatically advance to the next line after the [ENT] key is hit. Type the correction value for Longitude on the second line. For example, to enter 0.17 minutes East, use the following keystroke sequence:

   [CLR] [0] [0] [1] [7] [ENT]   00.17' East Correction

   Note that the [+/-] key cause the corrections to be entered in South Latitude and West Longitude.

5. Now you must define the GRI and the slave TD's where these corrections will automatically go into effect. Let us use an example of a geographic area which has not been surveyed by actual at-sea measurements of TD grid warpage: Japan. In this case we want to specify the GRI to be 9970 and the first two digits of S1 and to be 18 and 36 respectively. The following keystroke sequence would be appropriate once the cursor has automatically moved down to the third line after [ENT] was hit in step 4. above:

   [CLR] [9] [9] [7] [0] [ENT] [CLR] [1] [8] [ENT] [CLR] [3] [6] [ENT]

6. The above L/L offset values will now be applied whenever you are in the geographic area bounded by these values; in our example above, when you move the vessel to where the first two digits of the slave S1 are 18, and where the first two digits of the slave S2 are 36. Whenever L/L or TD corrections are automatically applied, a Δ T/L symbol will appear.

If by chance you try to specify a new page using the same GRI and slave station values that you have used for a previously specified page, the LC-90 will flash the GRI and slave offset values to warn you that in effect a contradictory command has been given to it.

TD Corrections (Function #2):

Normally, you will be using the LC-90 with automatic ASF corrections so that the L/L readout will be as accurate as possible. You may however enter your own TD correction factors if you want to do so, or if your particular geographic area doesn't have ASF compensation values available for it. The procedure to enter TD correction factors would be very similar to that above for L/L corrections, except that you wouldn't enter Latitude or Longitude corrections on line one and two after specifying a page number, but would proceed to lines four and five directly to specify GRI, S1, S2, and their associated TD correction values.

USING ASF WHEN ENTERING TD'S FOR WAYPOINTS

You will remember that cautions were given in section "INTERMEDIATE LEVEL OPERATIONS" concerning the necessity to Disable the automatic ASF compensation facility when you are trying to navigate to a waypoint defined by means of TD's. It was explained that if you tried to use the ASF capability on such a waypoint that you would in effect be counting the ASF twice, resulting in inaccurate L/L readings that would lead in turn to inaccurate bearings to steer whenever a R/B function is used.

You should also remember that we suggest that in general you should keep the automatic ASF compensation engaged for more accurate L/L readings. There is a way around this seeming contradiction in instructions when you are entering TD values for conversion to L/L coordinates and storage as waypoints. It involves a little more work on your part, but it will give more accurate R/B readings with ASF constantly engaged for all functions.

Basically, the process involves looking at Function #4 to determine what the actual values for the ASF compensation are, and then manually adding or subtracting the same values from whatever TD's you wish to enter into the LC-90 for conversion into a waypoint in the WPT Mode. An example should serve to illustrate this technique.

Assume that you are in the San Francisco area, at L/L coordinates of 37 degrees, 38 minutes North latitude and 122 degrees, 24 minutes West longitude. Call up Function #1. Make sure you are in the Automatic mode. (If you aren't in the Automatic mode you should turn off the [PWR] , call up Function #1, then call up the Automatic Selection process.) You will see that the optimum GRI is 9940, and that the LC-90 has automatically selected the slave secondaries 27 and 43. Now call up Function #4. The value for ASF for S1 (the 27 line) is +1.2 microseconds, and the value for ASF for S2 (the 43 line) is -0.4 microseconds. When the LC-90 is using the automatic ASF compensation facility it takes the TD's displayed on the front panel and adds these compensation values internally before making the TD to L/L conversion. You will be doing the same thing manually.

Let's say that your fishing buddy gives you a set of TD's where the fishing is particularly good, at 27260.0 and 43143.0 microseconds. To the 27260.0 value you would add the ASF of 1.2 microseconds, yielding 27261.2 microseconds. To the 43143.0 value you would add -0.4 microseconds, yielding 43142.6 microseconds. Now enter these into your "scratchpad" waypoint 99 by TD's (WPT Mode) and convert to L/L. The resulting L/L in WPT Mode will be:

37 degrees 39.00 minutes North latitude
122 degrees 23.94 minutes West longitude "Scratchpad" Waypoint 99

Now, a R/B calculation from present your present position to this waypoint (with the ASF enabled -- use Function #4) will result in the correct bearing to take for you to join up with your friend.

This method of specifying a waypoint by manually adding the ASF compensation values will allow you to keep the ASF function constantly engaged, and will result in less confusion when making any calculation involving waypoint(s), plus it will result in more accurate L/L readouts all the time.

MANUAL GRI/SLAVE SELECTION (Function #1)

So far you have been using your LC-90 on one Loran-C chain, and have been using the pair of slave stations selected automatically for you by the unit. In many geographic areas however there may be more than one pair of slave stations available.

The most important factors to consider when selecting slaves manually are: (1) TD Gradients, (2) Angle of Crossing, (3) Baseline Extension, and (4) Signal Strength. The operator should choose the best combination of TD's, taking into account all of these factors to obtain the best accuracy when operating the LC-90 manually. The values for GRI and the slave station selection chosen automatically by the LC-90 are derived from considerations of station geometry and signal strength for each geographic area. We are going to have to look again briefly at some basic Loran-C theory to give you some insight into how these considerations were derived.

TD Gradients:

Take a look again at Fig.1 on Page 5, where a section of chart was given showing an area off Yokohama, Japan. We determined that for the island of Mikura Jima there were three LOP's (TD's) that all crossed at its Southwestern corner, the 9970-X-36800, 9970-Y-60600 and 9970-W-17750 microsecond lines.

The spacing between adjacent TD's for the 9970-X TD's is 200 microseconds. The spacing between adjacent TD's for the 9970-Y TD's is also 200 microseconds. The spacing between adjacent TD's for the 9970-W TD's however is only 100 microseconds. What this means is that for any given change in position, the X and Y TD's change more than does the W TD. This phenomenon is known as "gradient," and denotes the amount of change of position for a given change of Time Difference.

Conversely, for any change in TD's for the X and Y TD's there would be a greater change in position than for the W TD's. Obviously, the smaller the position shift for a given change in TD's, the better the accuracy we can expect in determining our exact position.

There is however a fly in the ointment. While the W slave station would be a better choice (on the basis of gradient alone) in the area we are considering near Yokohama, the station is located farther away then the Y slave, which would otherwise be chosen to cross with the X TD's. The W signal thus might be weaker and thus less reliable than the Y signal, even with the less desirable gradient characteristics of the Y station. However, stations sometimes will go off the air for scheduled maintenance or because of a problem. At these times it may be necessary to choose manually another slave station in spite of the fact that it may show less than optimum geometry or signal strength in your area.

Angle of Crossing:

In an ideal Loran-C world all TD's would cross at an angle of 90 degrees. Unfortunately, we don't live in such a world, so we must consider the angle of crossing that actual TD's create. The closer the angle of crossing is to a right angle the better the accuracy of positioning will be. Close examination of Fig.1 shows that the X and the Y TD's cross at a better angle than do the X and the W TD's or the W and Y TD pair, and thus are a better choice to use. Note that the differences in angles of crossing of the X-Y, X-W, and Y-W pairs is really not dramatic. Sufficiently accurate navigational accuracy for for most purposes actually could be obtained by use of any of these pairs of TD's. It is merely better to use the more optimum X-Y pair. It is a general rule of thumb that you should be very wary of using TD pairs that cross at an angle less than 30 degrees.

The LC-90 will automatically select the preferred GRI as well as the preferred slaves for the desired position without user intervention if the Automatic function is in use; however, you may choose to use another GRI and/or slaves in your area if available. This is done by using the secondary Function #1.

1. Get into Function #1 by pressing [#] followed by [1]. On the third line of the resulting display the label "GRI" will be followed by a flashing "A," indicating that automatic operation has been selected previously. This must be disabled to use manual operation. Press [CLR] [+/-] (followed by a four digit code for a GRI if you wish to change the GRI also), and then press [ENT]. A "d" will appear replacing the "A." You will now have to select the proper slaves to use.

2. For example, if the slaves automatically selected were "27" and "43," and you wish to use "27" and "11," move the cursor down to the fifth line and hit [CLR] [1] [1] [ENT].

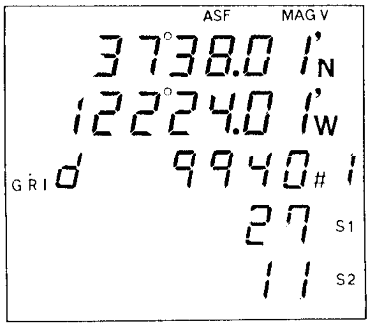


Fig. 44 Function #1 Screen

HOLDING THE TRACKING POINT (Function #7)

This is another function which is provided as an aid for servicing technicians.

The LC-90 tracks on the third cycle of the pulse. The signal amplitude at this point is not terribly high, so under high noise or at the extreme limits of its range, the receiver may automatically track the signal at a latter cycle (high SNR point).

If you set the "Tracking Point" to "Hold" mode, the receiver tracks the signal at the correct point and you can read how poor the SNR might be.

Press [CLR] [+/-] and [ENT] on the third line of the secondary Function #7. The legend "Hold" appears instead of "Free" to indicate that Cycle selection has now been frozen.

SELECTING OUTPUT DATA FORMAT (Function #3)

The LC-90 sends out to external devices (such as plotters and printers) the position and autopilot data through a connector on the rear panel. The position data may be sent out in either Furuno CIF format (Computer InterFace) or in the NMEA 0183 complex format. The autopilot data is sent out in the NMEA 0180 simple format. To choose the format for the output data access Function #3, then use the following touchpad sequence:

1. Hit the down arrow key once to move the cursor down to the third line.
2. Press [CLR]. Pressing the [+/-] key will alternate the display between the following output data formats:

   "CIF," for Furuno CIF (Computer InterFace)

   "dSP," for Display of display screen on outside terminal. (To be announced later.)

   "183," for NMEA 0183 data format output.
3. Select the desired output format (CIF or 0183), and press [ENT].
4. Once the [ENT] key is pressed, the cursor will advance to the next line, where you may select the autopilot output format. Many modern pilots are designed to interface with a Loran-C receiver that produces the NMEA 0180 simple data format. In the future it is expected that some autopilots will be able to use the more complicated NMEA 0183 complex format. For now, though, if you want to interface your compatible pilot with the LC-90, you would select the 0180 format on the fourth line.

   [CLR] [+/-] (to show "180") and then press [ENT].

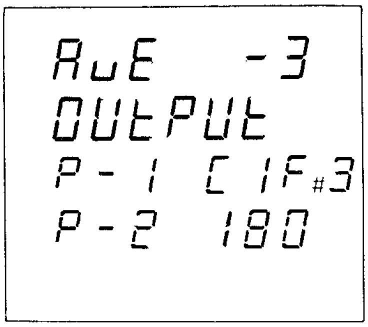


Fig. 45 Function #3 Screen

TUNING INDICATION (Function #8)

The LC-90 provides a "Tuning Indication" in secondary function #8, moinitoring the signal strength in frequency range between 70 and 140 KHz. The chosen frequency is shown on the display, and the signal level is indicated by a series of bars.

Get into Function #8 by pressing [#] and [8]. The frequency selected is displayed on the third line next to "Fr." To change the frequency, push the ▲ and ▼ arrows. The number of bars appearing in the three lines above "Tune" vary according to signal strength. Twenty bars indicates maximum signal strength.

TROUBLESHOOTING

Self-Check 1:

As already described, the LC-90 carries out its self-check automatically, each time power is turned on. If the self-check sequence detects a failure on the CPU board, an error message "ro 1", "ro 2", "rA", C1 xxx" or C2 x" will be displayed. ("x" in the preceding messages stands for a digit of some sort.) If one of these messages are displayed, the CPU board (04P4044) should be replaced with a new one.

Self-Check 2:

This self-check 2 is provided to check the LCD display, the output data to the peripheral equipment and the keyboard. To perform this check, press the [ENT] key just after the [PWR] key is pressed. Hold the [ENT] key down until you hear two beeps, and then you may release it.

The display will go through the following sequence automatically until the unit is turned off. There are two sequences in accordance with the following initial setup conditions. If you insert a test plug, made locally using an SRC connector (type: SRCN6A16-10P, Code No.000-508-663); pins #2, #4 and #6 shorted together, and pins #1 and #3 shorted together), and if you run Self-Check 2 without the test plug.

Without test plug:

1) The message "A9n9" will appear on the display.

2) This display will change to "td2 Err." Because no test plug is connected.

3) After a while, "LED tESt" will be displayed, and then all segments of the LCD display will come on.

4) Then a series of bars corresponding to the touchpad key positions will be displayed after the message "kEy tESt" has appeared on screen.

5) Press each keypad, confirming the change of the corresponding bar to "8" on the display.

6) To end the test, press the [PWR] and [OFF] keys simultaneously.

With test plug:

1) The message "A9n9" will appear on the display.

2) If the error message "td1 Err" or Td2 Err" is displayed, the data output circuit is likely to be faulty. Replace the CPU board.

3) Now follow the steps 3) through 6) above.

Remember that an unusual symptom may be caused not only by a faulty circuit but also by Loran-C signal conditions, or even operator error.

1. Signal Interference (Quality)

Signal quality is very important in determining the exact point at which the receiver locks onto and tracks the signals. A poor signal causes erratic indications and tracking may occasionally be interrupted. The signal quality can be checked with the CYC/SNR indicators and the SNR/ECD display. Select another secondary or chain if it is confirmed that the signal is too weak or distorted.

2. Defective Loran Transmitters

The "BLINK" warning indicators are provided to indicate the condition of the transmitting stations. The warning indicator comes on automatically when abnormal conditions exist of one or more stations.

3. Inadequate Unit Installation

The performance of LC-90 largely depends upon its installation; especially antenna location, grounding and noise suppression. This problem will probably require the assistance of your dealer.

4. Improper Operation

This requires the operator to consult the instruction manual or ask a dealer for assistance.

The following pages contain lists of specific symptoms and remedies.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Nothing appears.	1. Switch at main switch-board is turned off.	1. Turn on the main switch.
	2. Power plug is loose or out.	2. Secure it firmly.
	3. "MAIN" fuse(2A) at rear panel has blown.	3. Check mains voltage and polarity first, and put new fuse. If blown again, call for service. When driven from AC mains, check rectifier unit too.
	4. Faulty circuit.	4. Call for service.
Display doesn't complete self-check.	1. Faulty circuit.	1. Call for service. If any number if displayed on one of the readouts, note and tell service technician.
TD of unselected slave, having larger coding-delay, appears.	1. Selected slave is off-the-air.	1. Call up coast station or ask neighboring boats for signal conditions.
Large amount of error in both S1 and S2 TD's.	1. Long-delayed skywave of master signal has been acquired.	1. Turn off and repeat whole acquisition sequence.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Large amount of error only in S1 or S2 TD.	1. Long-delayed skywave of the slave signal has been acquired. 2. The slave is off-the-air.	1. Repeat the slave signal acquisition. 2. Call up coast station or ask neighboring boats for signal conditions.
10us step error in S1 or S2 TD(10, 20 or 30us).	1. The slave station is too close (30 n.m. or less) or too far (750 n.m. or more). 2. Over-land signal is received.	1. Correct it manually. 2. Correct it manually.
Same amount of 10us step error in both S1 and S2 TD's.	1. The master station is too close (30 n.m. or less) or too far (750 n.m. or more). 2. Over-the-land-master signal is received.	1. Correct it manually. 2. Same as above.
SNR indicator on.	1. Signal is weak. 2. The station is off-the-air. 3. Heavy interference exists.	1. Check SNR reading. If available, select another slave or chain. 2. Call up coast station or ask neighboring boats for signal conditions. 3. Readjust notch filter.
CYC indicator on occasionally.	1. Over-the-land signal is received.	1. Watch TD's carefully before position fixing.
Degree label on L/L display blinks.	1. Signal is weak.	1. Check SNR reading. If available, select another slave or chain.
PF indicator on.	1. Power went off but recovered sometime in the past. Position reading may be suspect.	1. If the display is in error, turn off the unit and search signals again or use manual tracking function, #5.

NOTE:

For some Loran chains, current status and schedules of the chain operation are provided on a prerecorded telephone service in the U.S.A.

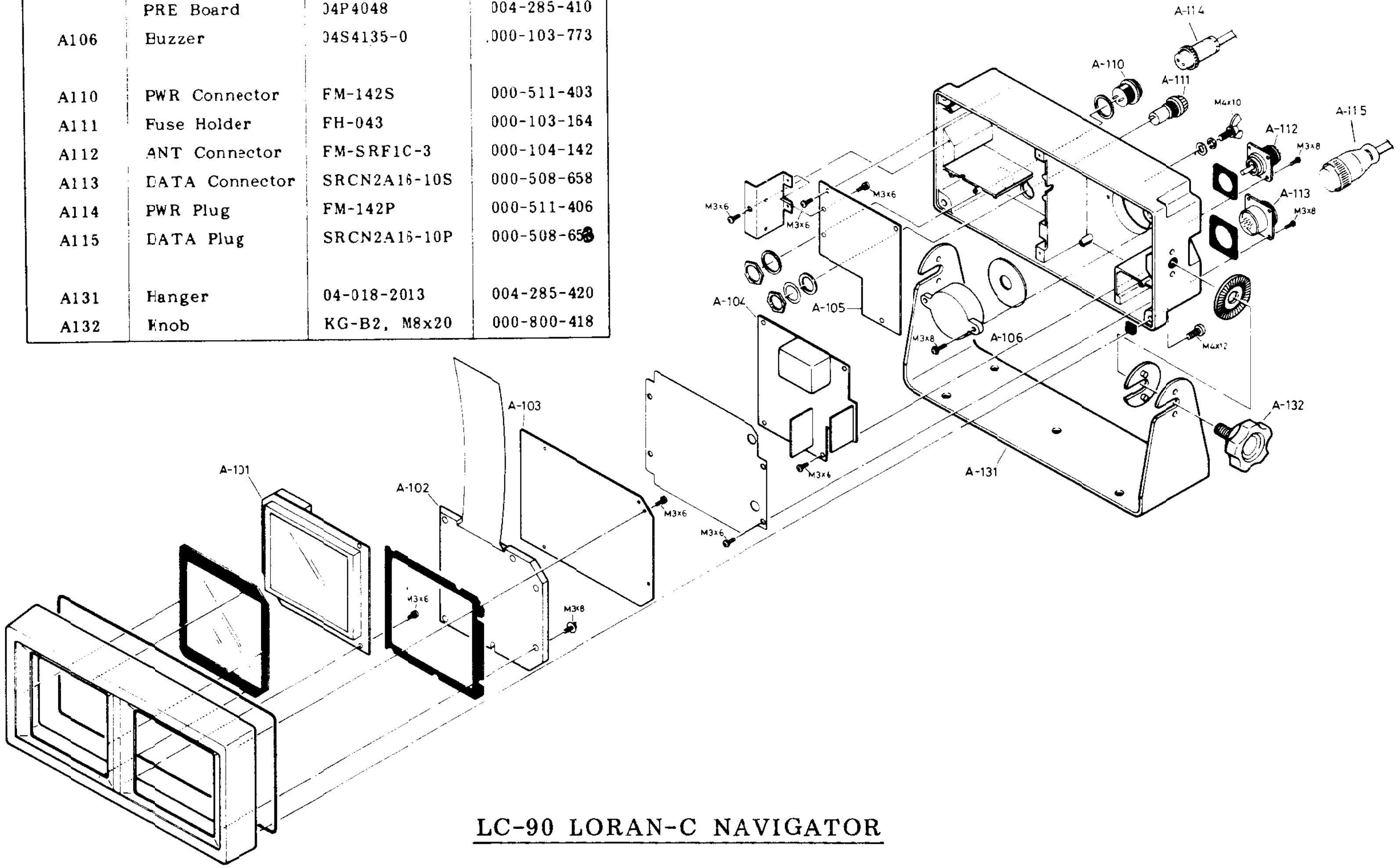
9960/8970/7980 Chains ...... Tel.;607-869-5395 (Lorstas Seneca, NY)
904-569-5241 (Malone, FL)

(Consult your dealer or service agent about how to obtain the latest Loran information.)

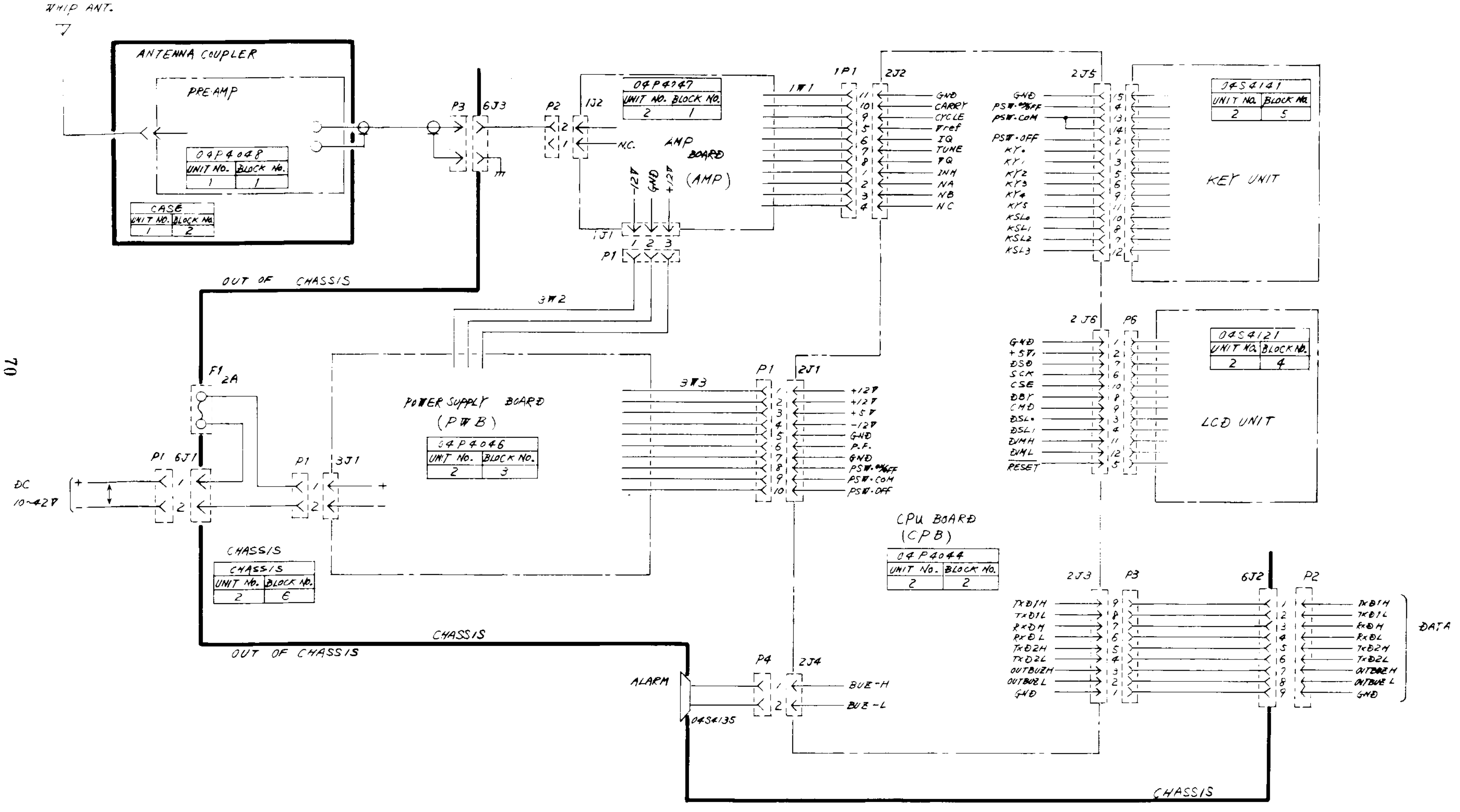
REPLACEMENT OF KEEP-ALIVE BATTERY

The estimated life of the "Keep-alive" battery is three years. However, to ensure trouble-free operation, it is suggested that the battery be replaced every three years with an exact replacement. Please ask your dealer.

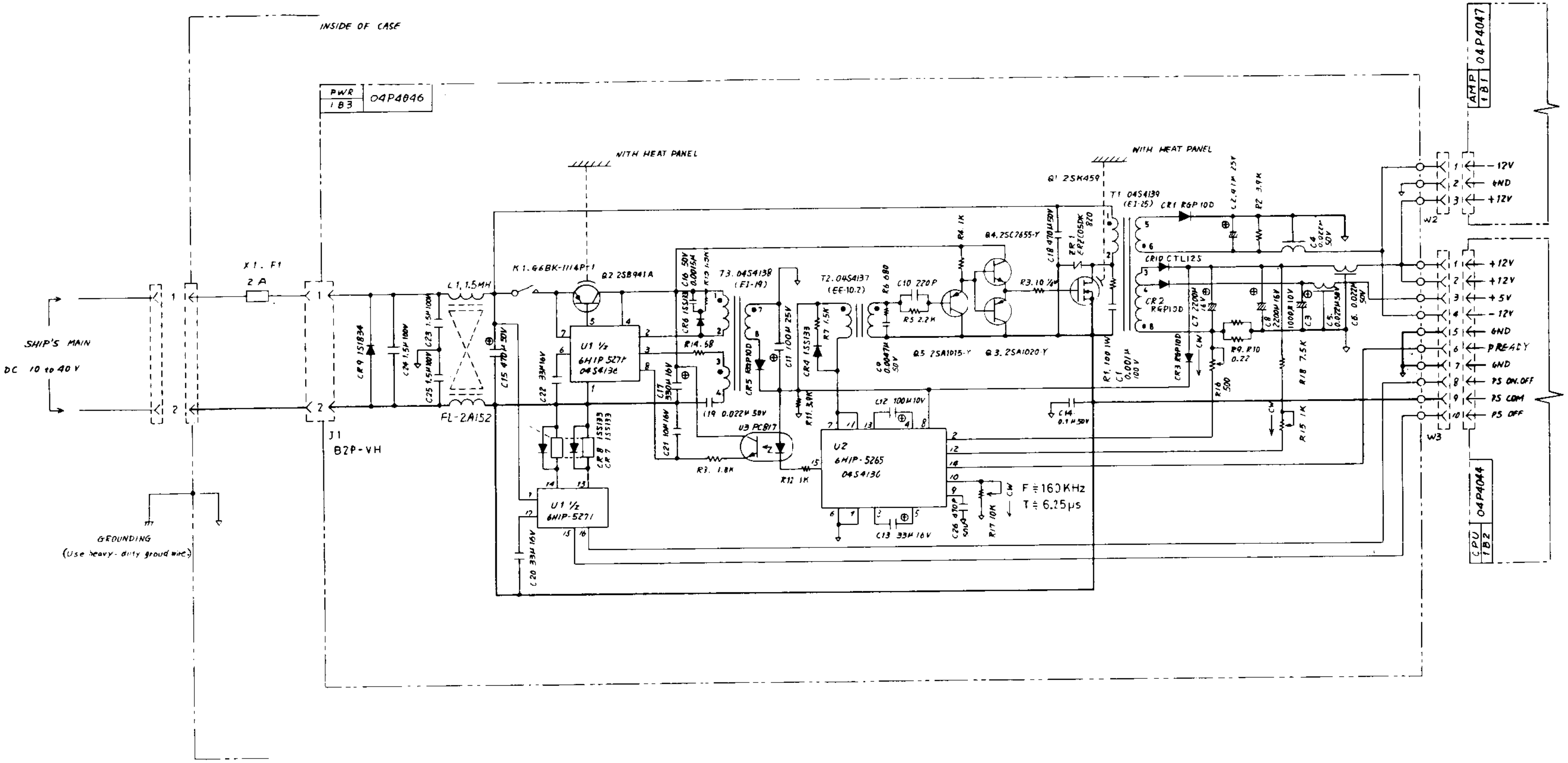
SYMBOL	NAME	TYPE	CODE NO.
A101	LCD Display	04S4121-0	000-103-765
A102	Keyboard	04S4141-0	000-103-770
A103	CPU Board	04P4044	004-285-360
A104	Power Board	04P4046	004-285-330
A105	AMP Board	04P4047	004-285-390
	PRE Board	04P4048	004-285-410
A106	Buzzer	04S4135-0	000-103-773
A110	PWR Connector	FM-142S	000-511-403
A111	Fuse Holder	FH-043	000-103-164
A112	ANT Connector	FM-SRF1C-3	000-104-142
A113	DATA Connector	SRCN2A16-10S	000-508-658
A114	PWR Plug	FM-142P	000-511-406
A115	DATA Plug	SRCN2A16-10P	000-508-65[illegible]
A131	Hanger	04-018-2013	004-285-420
A132	Knob	KG-B2, M8x20	000-800-418



LC-90 LORAN-C NAVIGATOR



LC-90 LORAN-C NAVIGATOR



LC-90 POWER SUPPLY CIRCUIT

APPENDIX A

REFERENCES

CHARTS OF VARIOUS LORAN-C CHAINS SHOWING RECOMMENDED TD PAIRS:

List of Contents

NORTHWEST PACIFIC (9970)............................ APA-2

CENTRAL PACIFIC (4990).............................. APA-2

NORTH PACIFIC (9990)................................ APA-3

GULF OF ALASKA (7960)............................... APA-3

CANADIAN WEST COAST (5990).......................... APA-4

U.S. WEST COAST (9940).............................. APA-4

SOUTHEAST U.S. (7980)............................... APA-5

NORTHEAST U.S. (9960)............................... APA-5

GREAT LAKES (8970).................................. APA-6

CANADIAN EAST COAST (5930).......................... APA-6

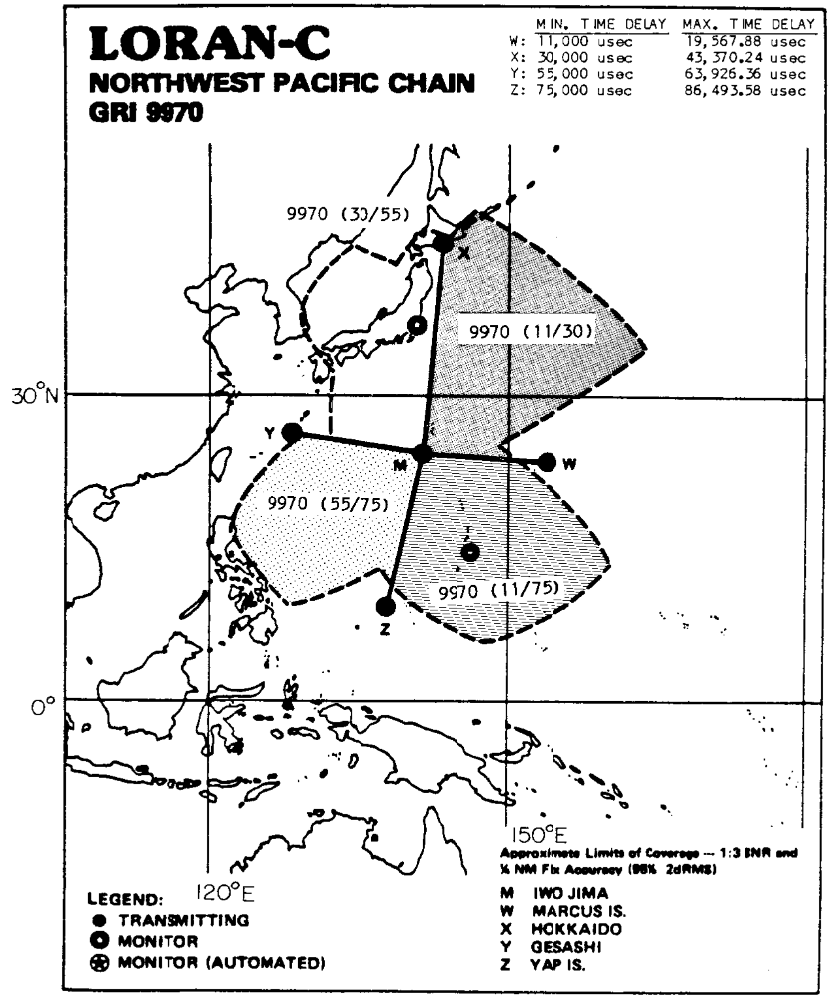
ICELANDIC (9980) APA-7

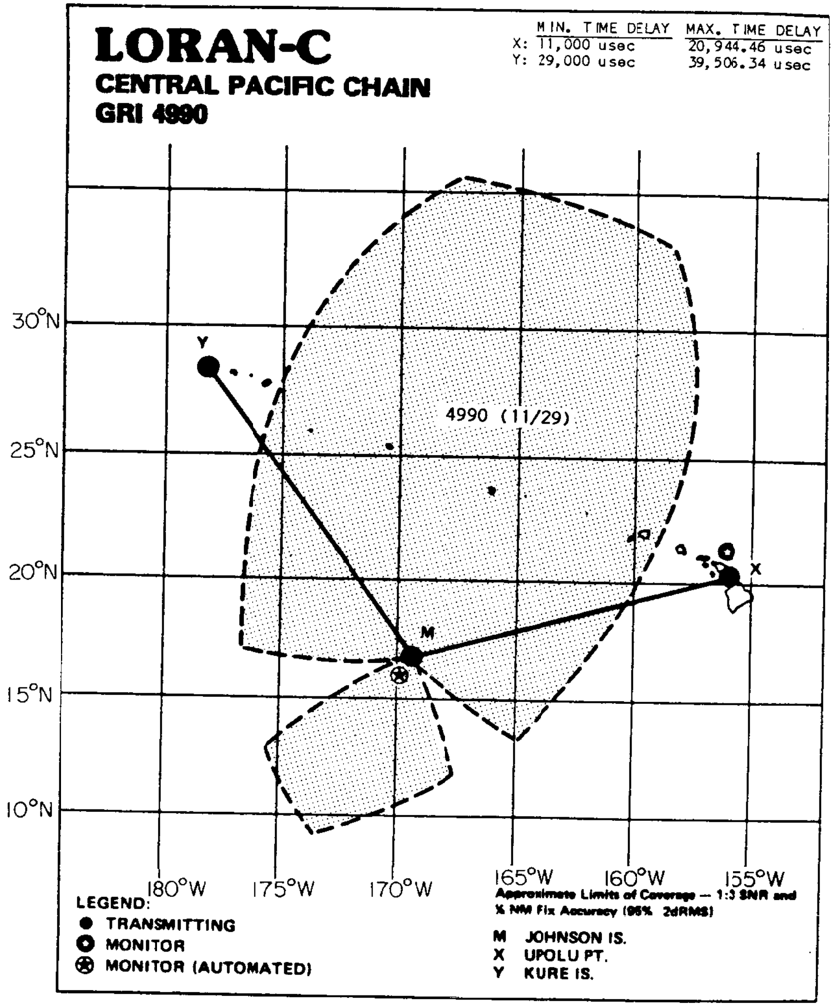
NORWEGIAN SEA (7970)................................ APA-7

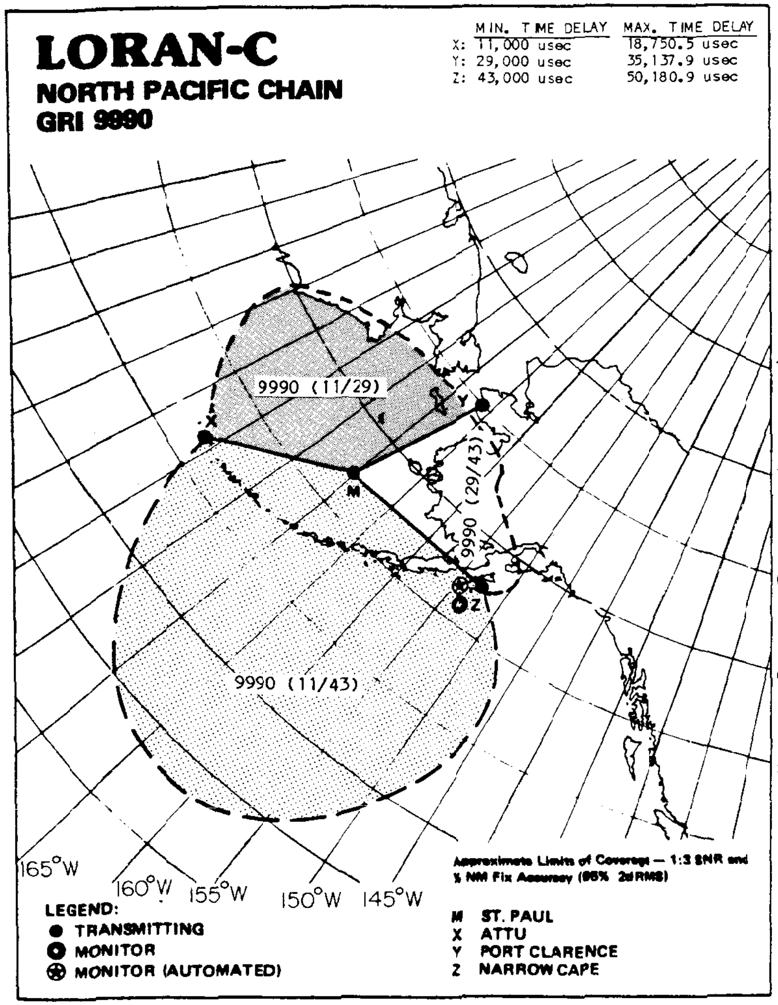
MEDITERRANEAN SEA (7990) APA-8

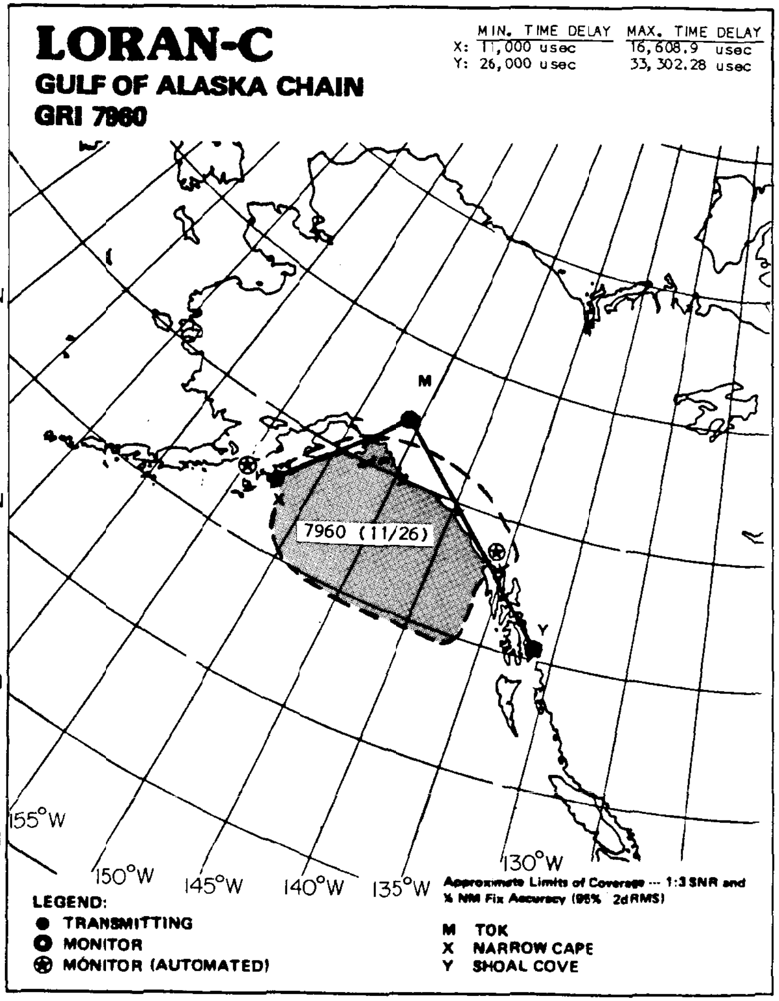
COMMANDO LION CHAIN (5970) APA-8

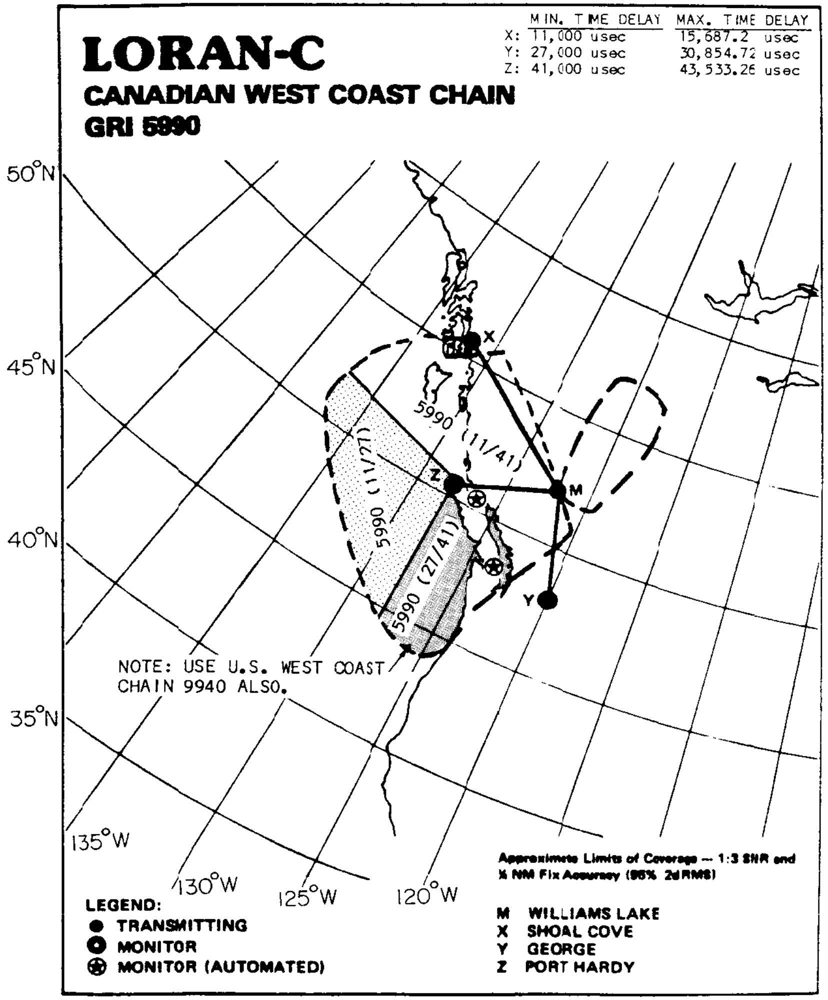
LABRADOR SEA (7930) APA-9

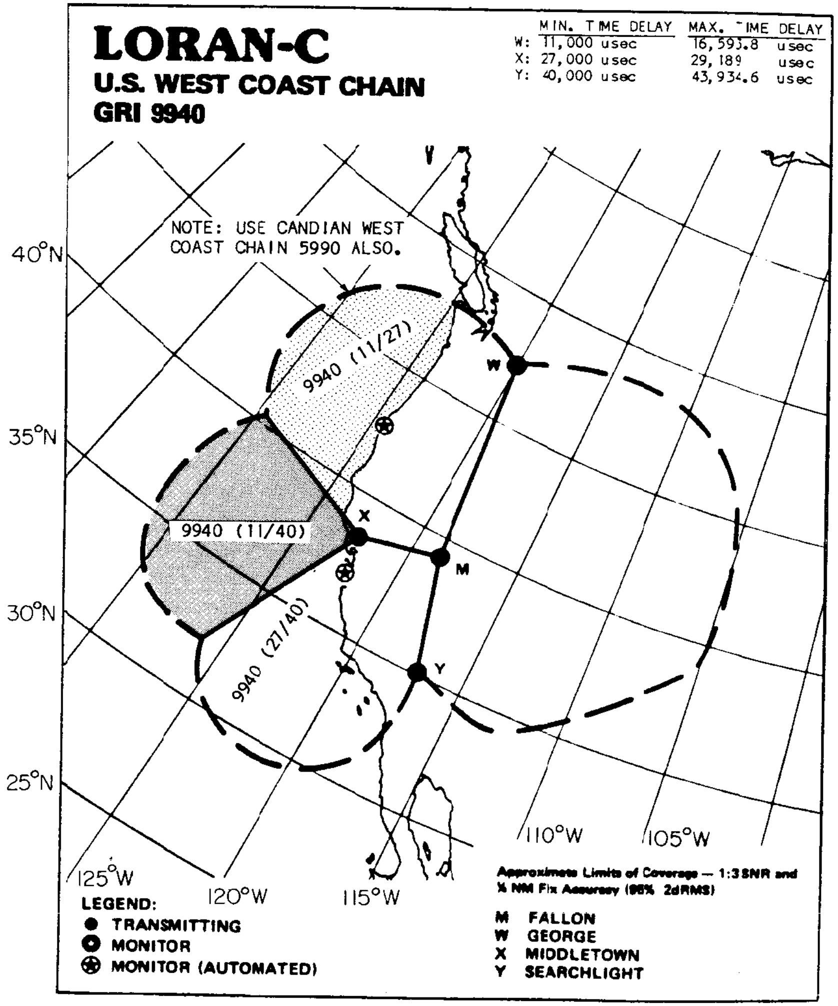

LORAN-C
NORTHWEST PACIFIC CHAIN
GRI 9970
MIN. TIME DELAY
MAX. TIME DELAY
W: 11,000 usec 19,567.88 usec
X: 30,000 usec 43,370.24 usec
Y: 55,000 usec 63,926.36 usec
Z: 75,000 usec 86,493.58 usec
9970 (30/55)
9970 (11/30)
9970 (55/75)
9970 (11/75)
30°N
0°
120°E
150°E
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M IWO JIMA
W MARCUS IS.
X HOKKAIDO
Y GESASHI
Z YAP IS.

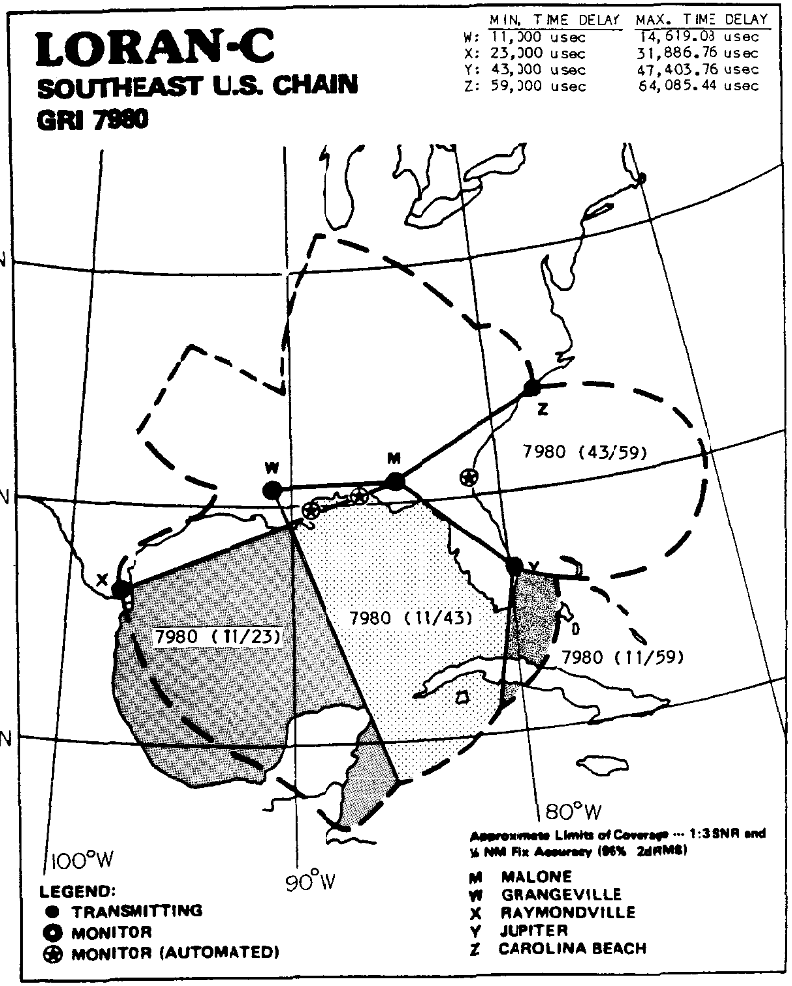

LORAN-C
CENTRAL PACIFIC CHAIN
GRI 4990
MIN. TIME DELAY
MAX. TIME DELAY
X: 11,000 usec 20,944.46 usec
Y: 29,000 usec 39,506.34 usec
4990 (11/29)
30°N
25°N
20°N
15°N
10°N
180°W
175°W
170°W
165°W
160°W
155°W
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M JOHNSON IS.
X UPOLU PT.
Y KURE IS.

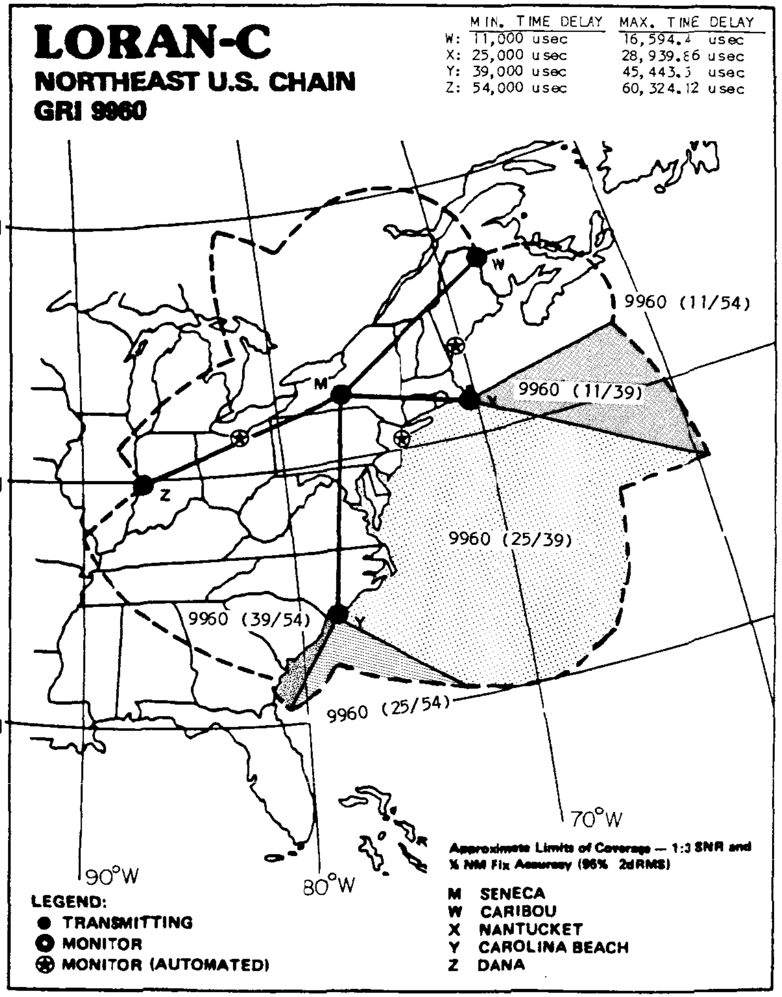

LORAN-C
NORTH PACIFIC CHAIN
GRI 9990
MIN. TIME DELAY
MAX. TIME DELAY
X: 11,000 usec 18,750.5 usec
Y: 29,000 usec 35,137.9 usec
Z: 43,000 usec 50,180.9 usec
9990 (11/29)
9990 (29/43)
9990 (11/43)
75°N
70°N
65°N
60°N
55°N
165°W
160°W
155°W
150°W
145°W
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M ST. PAUL
X ATTU
Y PORT CLARENCE
Z NARROW CAPE

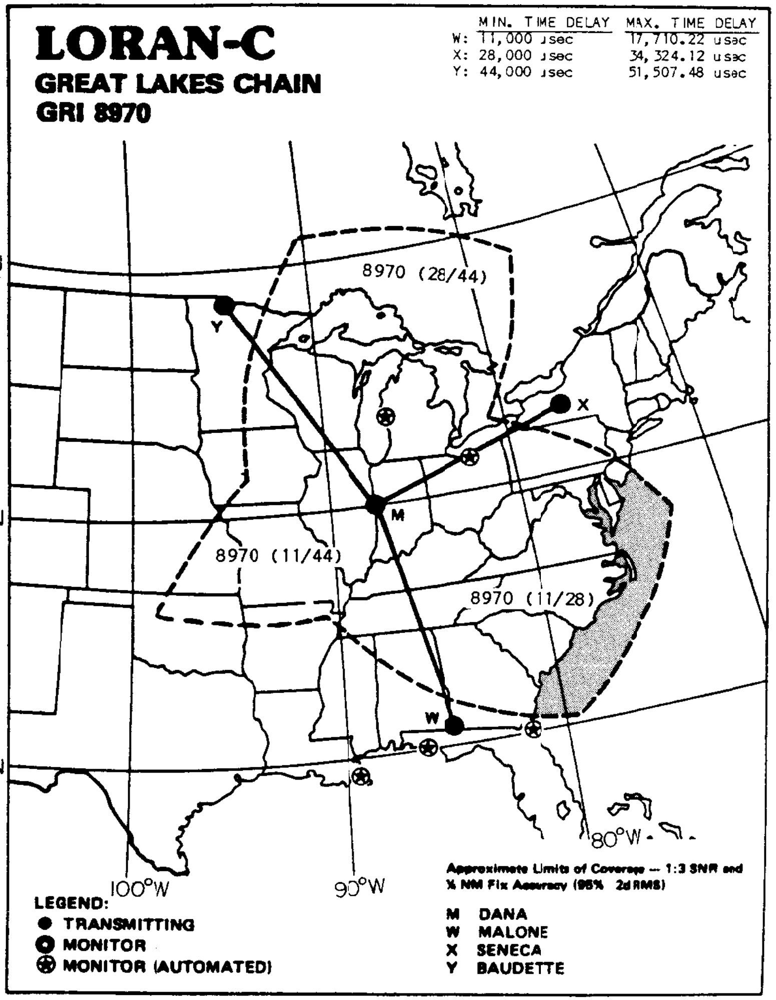

LORAN-C
GULF OF ALASKA CHAIN
GRI 7960
MIN. TIME DELAY
MAX. TIME DELAY
X: 11,000 usec 16,608.9 usec
Y: 26,000 usec 33,302.28 usec
7960 (11/26)
60°N
55°N
50°N
45°N
155°W
150°W
145°W
140°W
135°W
130°W
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M TOK
X NARROW CAPE
Y SHOAL COVE

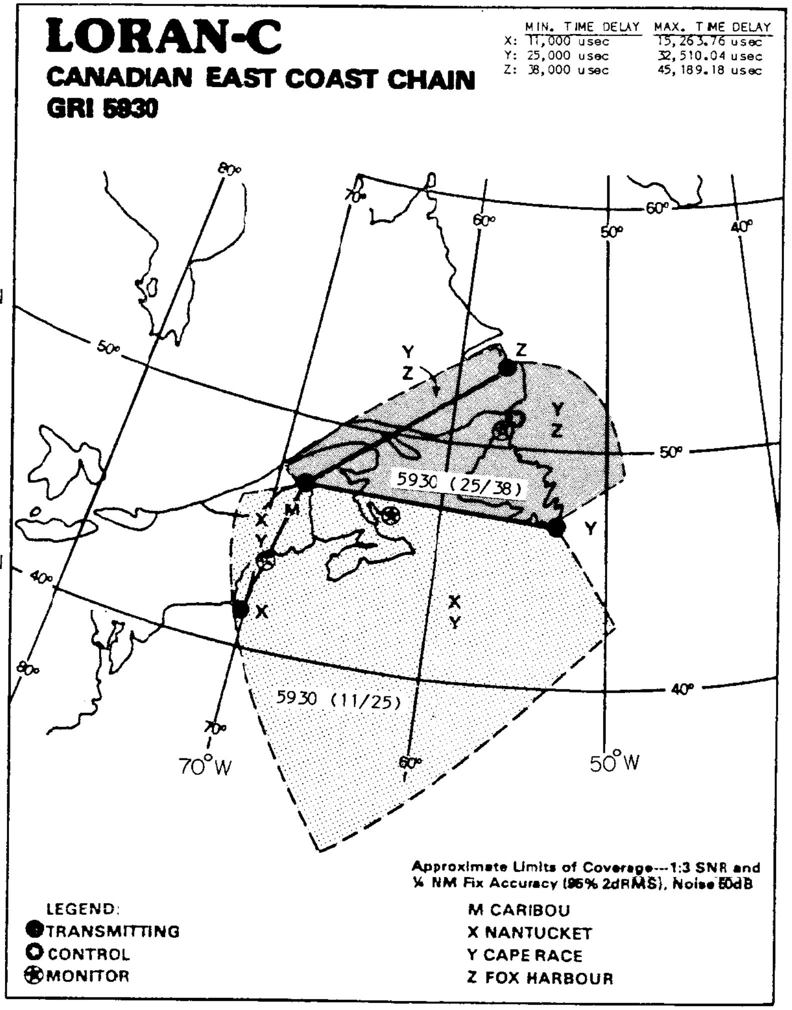

LORAN-C
CANADIAN WEST COAST CHAIN
GRI 5990
MIN. TIME DELAY | MAX. TIME DELAY
X: 11,000 usec | 15,687.2 usec
Y: 27,000 usec | 30,854.72 usec
Z: 41,000 usec | 43,533.26 usec
50°N
45°N
40°N
35°N
135°W
130°W
125°W
120°W
5990 (11/41)
5990 (11/27)
5990 (27/41)
NOTE: USE U.S. WEST COAST CHAIN 9940 ALSO.
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
M WILLIAMS LAKE
X SHOAL COVE
Y GEORGE
Z PORT HARDY

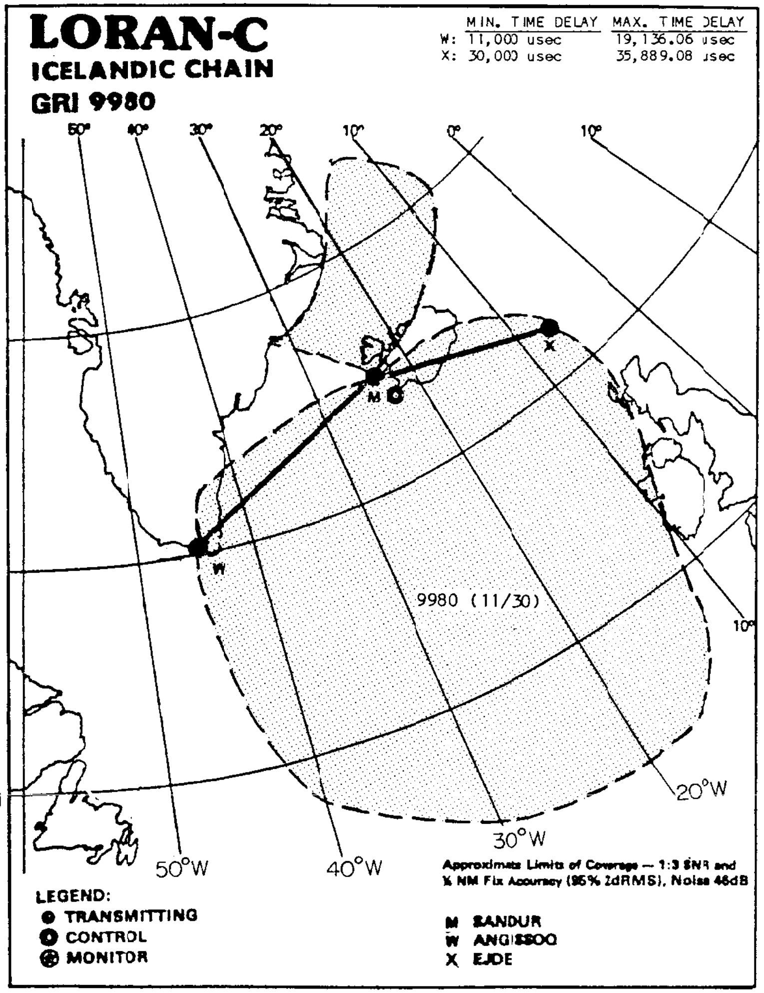

LORAN-C
U.S. WEST COAST CHAIN
GRI 9940
MIN. TIME DELAY | MAX. TIME DELAY
W: 11,000 usec | 16,593.8 usec
X: 27,000 usec | 29,189 usec
Y: 40,000 usec | 43,934.6 usec
40°N
35°N
30°N
25°N
125°W
120°W
115°W
110°W
105°W
NOTE: USE CANDIAN WEST COAST CHAIN 5990 ALSO.
9940 (11/27)
9940 (11/40)
9940 (27/40)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
M FALLON
W GEORGE
X MIDDLETOWN
Y SEARCHLIGHT

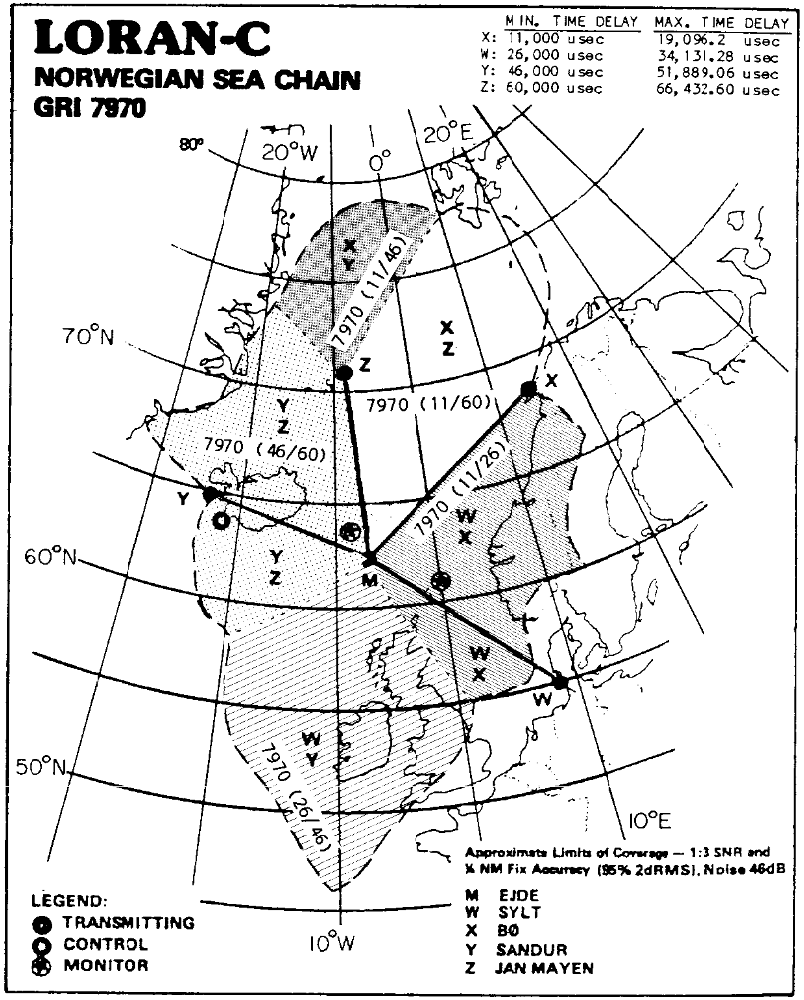

LORAN-C
SOUTHEAST U.S. CHAIN
GRI 7980
MIN. TIME DELAY / MAX. TIME DELAY
W: 11,000 usec 14,619.03 usec
X: 23,000 usec 31,886.76 usec
Y: 43,000 usec 47,403.76 usec
Z: 59,000 usec 64,085.44 usec
40°N
30°N
20°N
100°W
90°W
80°W
7980 (43/59)
7980 (11/23)
7980 (11/43)
7980 (11/59)
W
M
X
Y
Z
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M MALONE
W GRANGEVILLE
X RAYMONDVILLE
Y JUPITER
Z CAROLINA BEACH


LORAN-C
NORTHEAST U.S. CHAIN
GRI 9960
MIN. TIME DELAY / MAX. TIME DELAY
W: 11,000 usec 16,594.4 usec
X: 25,000 usec 28,939.86 usec
Y: 39,000 usec 45,443.3 usec
Z: 54,000 usec 60,324.12 usec
50°N
40°N
30°N
90°W
80°W
70°W
9960 (11/54)
9960 (11/39)
9960 (25/39)
9960 (39/54)
9960 (25/54)
W
M
X
Y
Z
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M SENECA
W CARIBOU
X NANTUCKET
Y CAROLINA BEACH
Z DANA


LORAN-C
GREAT LAKES CHAIN
GRI 8970
MIN. TIME DELAY MAX. TIME DELAY
W: 11,000 μsec 17,710.22 μsec
X: 28,000 μsec 34,324.12 μsec
Y: 44,000 μsec 51,507.48 μsec
50°N
40°N
30°N
100°W
90°W
80°W
8970 (28/44)
8970 (11/44)
8970 (11/28)
Y
X
M
W
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS)
LEGEND:
TRANSMITTING
MONITOR
MONITOR (AUTOMATED)
M DANA
W MALONE
X SENECA
Y BAUDETTE

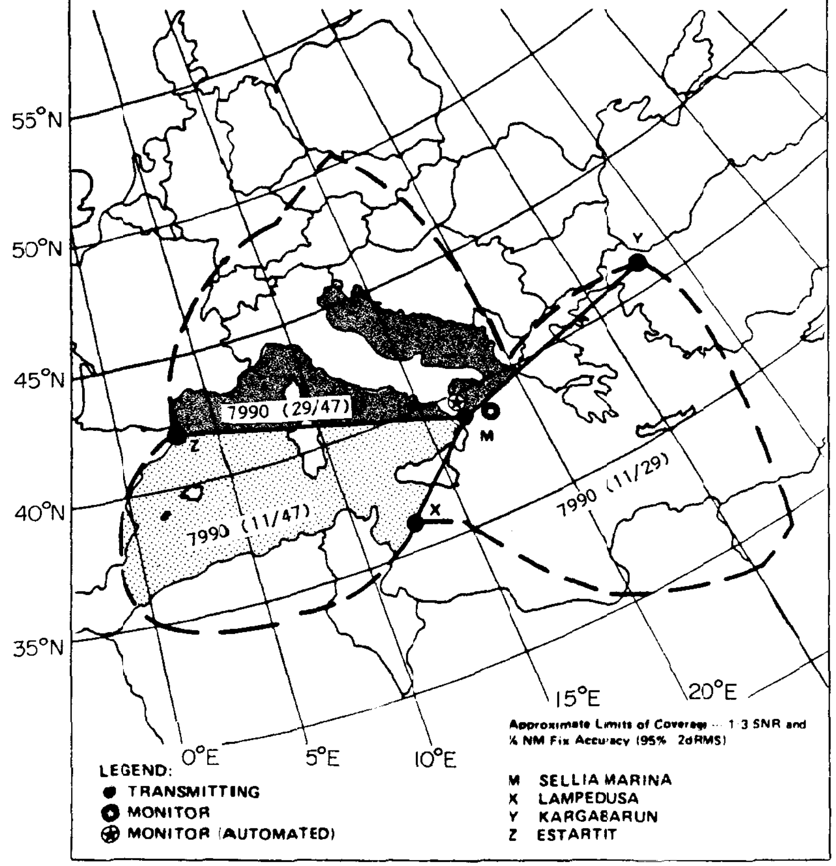

LORAN-C
CANADIAN EAST COAST CHAIN
GRI 5930
MIN. TIME DELAY MAX. TIME DELAY
X: 11,000 usec 15,263.76 usec
Y: 25,000 usec 32,510.04 usec
Z: 38,000 usec 45,189.18 usec
50°N
40°N
70°W
50°W
5930 (25/38)
5930 (11/25)
Approximate Limits of Coverage—1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS), Noise 50dB
LEGEND:
TRANSMITTING
CONTROL
MONITOR
M CARIBOU
X NANTUCKET
Y CAPE RACE
Z FOX HARBOUR


LORAN-C
ICELANDIC CHAIN
GRI 9980
MIN. TIME DELAY
MAX. TIME DELAY
W: 11,000 usec 19,136.06 usec
X: 30,000 usec 35,889.08 usec
70°N
60°N
50°N
50°W
40°W
30°W
20°W
9980 (11/30)
Approximate Limits of Coverage — 1:3 SNR and ½ NM Fix Accuracy (95% 2dRMS), Noise 46dB
LEGEND:
TRANSMITTING
CONTROL
MONITOR
M SANDUR
W ANGISSOQ
X EJDE


LORAN-C
NORWEGIAN SEA CHAIN
GRI 7970
MIN. TIME DELAY
MAX. TIME DELAY
X: 11,000 usec 19,096.2 usec
W: 26,000 usec 34,131.28 usec
Y: 46,000 usec 51,889.06 usec
Z: 60,000 usec 66,432.60 usec
80°
20°W
0°
20°E
70°N
60°N
50°N
10°W
10°E
7970 (11/46)
7970 (11/60)
7970 (46/60)
7970 (11/26)
7970 (26/46)
Approximate Limits of Coverage — 1:3 SNR and ½ NM Fix Accuracy (95% 2dRMS), Noise 46dB
LEGEND:
TRANSMITTING
CONTROL
MONITOR
M EJDE
W SYLT
X BØ
Y SANDUR
Z JAN MAYEN

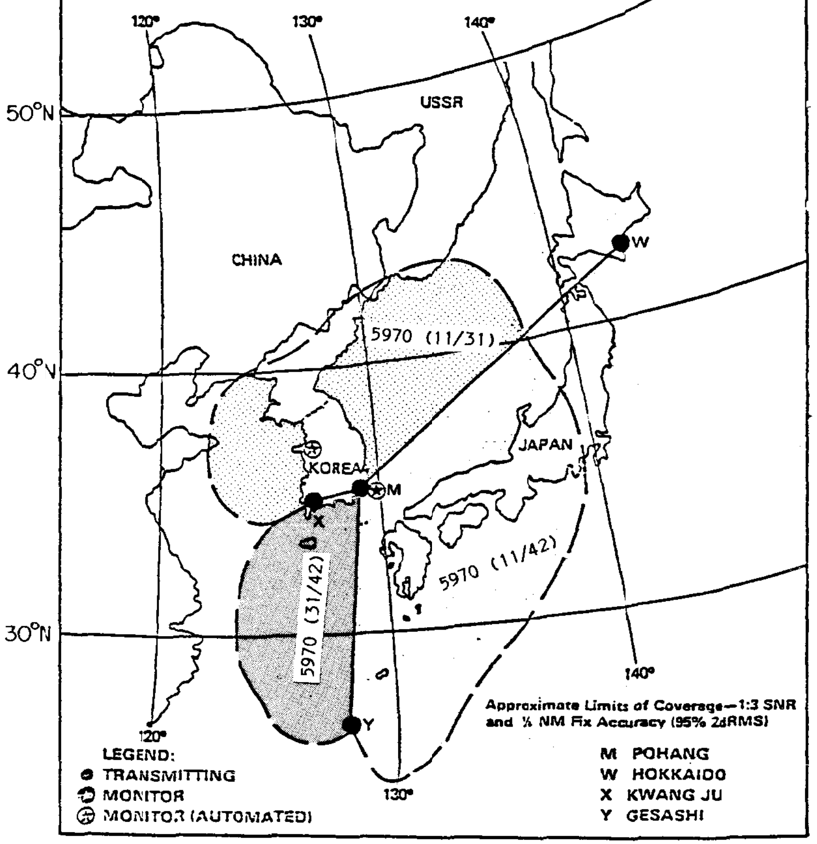
LORAN-C
MEDITERRANEAN CHAIN
GRI 7990

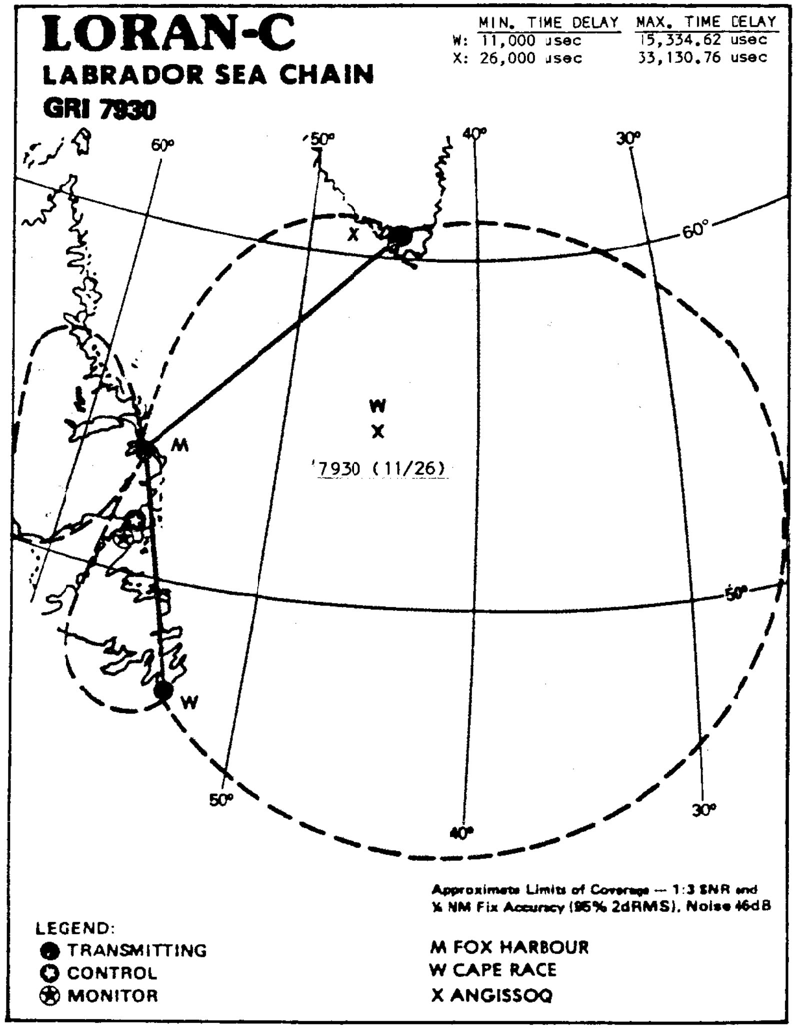
	MIN. TIME DELAY	MAX. TIME DELAY
X:	11,000 usec	14,511.96 usec
Y:	29,000 usec	35,546.58 usec
Z:	47,000 usec	54,999.42 usec



LORAN-C
COMMANDO LION CHAIN
GRI 5970

	MIN. TIME DELAY	MAX. TIME DELAY
W:	11,000 usec	20,567.36 usec
X:	31,000 usec	32,894.04 usec
Y:	42,000 usec	49,131.12 usec




LORAN-C
LABRADOR SEA CHAIN
GRI 7930
MIN. TIME DELAY
W: 11,000 usec
X: 26,000 usec
MAX. TIME DELAY
15,334.62 usec
33,130.76 usec
60°
50°
40°
30°
M
W
X
7930 (11/26)
Approximate Limits of Coverage — 1:3 SNR and ¼ NM Fix Accuracy (95% 2dRMS), Noise 46dB
LEGEND:
TRANSMITTING
CONTROL
MONITOR
M FOX HARBOUR
W CAPE RACE
X ANGISSOQ